LSCO. Report No. - 2123-2.0-4-l



TECHNOLOGY TRANSFER PROGRAM [TTP]

FINAL REPORT

ENGINEERING & DESIGN

# ENGINEERING & DESIGN
# VOLUME 2 APPENDICES

Prepared by:

Levingston Shipbuilding Company
in conjunction with:
IHI Marine Technology, Inc.

December 22, 1980

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE **30 JUN 1981** | 2. REPORT TYPE **N/A** | 3. DATES COVERED **-** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE **Technology Transfer Program (TTP) Engineering & Design Volume 2 Appendices** | 5a. CONTRACT NUMBER |
| | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128-9500 MacArthur Blvd Bethesda, MD 20817-5700** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT **unclassified** | b. ABSTRACT **unclassified** | c. THIS PAGE **unclassified** | **SAR** | **435** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

70459

# APPENDIX A

## BRIEF EXPLANATION OF IHICS

SYS.ENG.GRP.

# BRIEF EXPLANATION
# OF
# IHICS

Integrated Hull Information Control System

ISHIKAWAJIMA-HARIMA IHI HEAVY INDUSTRIES

OCT. 1978


Ishikawajima-Harima

Heavy industries Co., Ltd.

TOKYO JAPAN


REF. No.

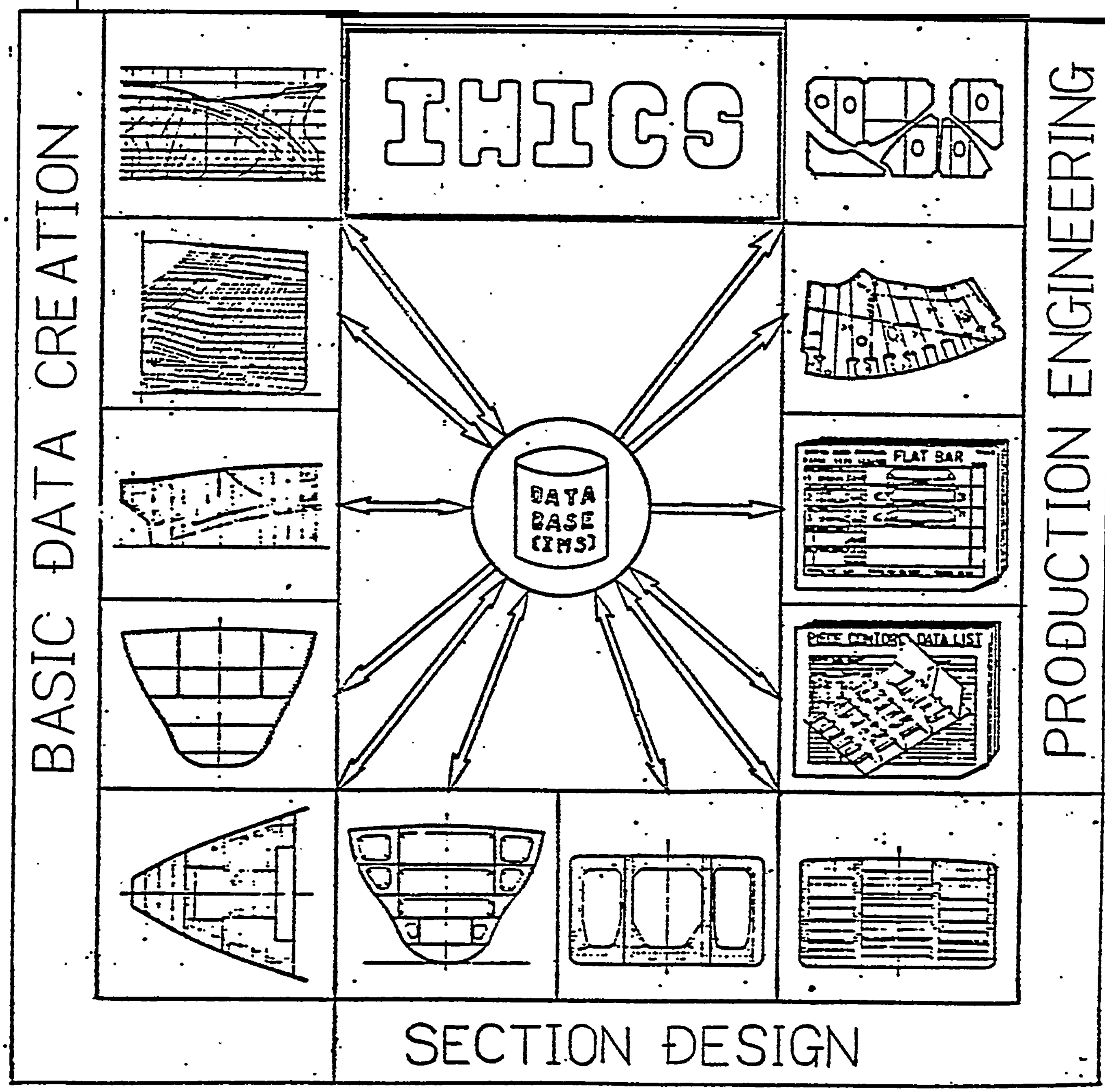
HL-781003

CONTENTS

70459

## INTRODUCTION

IHICS (Intergrated Hull Information Control System) is a series of program packages which assists engineers in the fields of design and production engineering of hull construction, and also furnishes them with all informations necessary for the execution of production.



1. Problems in Manufacturing Division.

   There are many problems in the manufacturing division of shipbuilding today.

   (A) Increase of ship's type to be constructed which has been caused by ship's market.

   (B) The method of transmission of the large volume information and data from the design division to the manufacturing division, for instance,

   -Numerical Control Data

   -Production Engineering Data

   -Production Control Data

   (C) Requirements of highly precise data and information.

   (D) Delivery in short time

2. IHICS solves the above problems.

   (A) Generates the engineering and production data from a small volume of input data prepared by engineers.

   (B) Assists engineers in the design and production engineering activity.

   (C) Creates the full part data base which supplies following information to the manufacturing division.

   Information of production engineering.

   Numerical Control Data.

   Piece list for each stage.

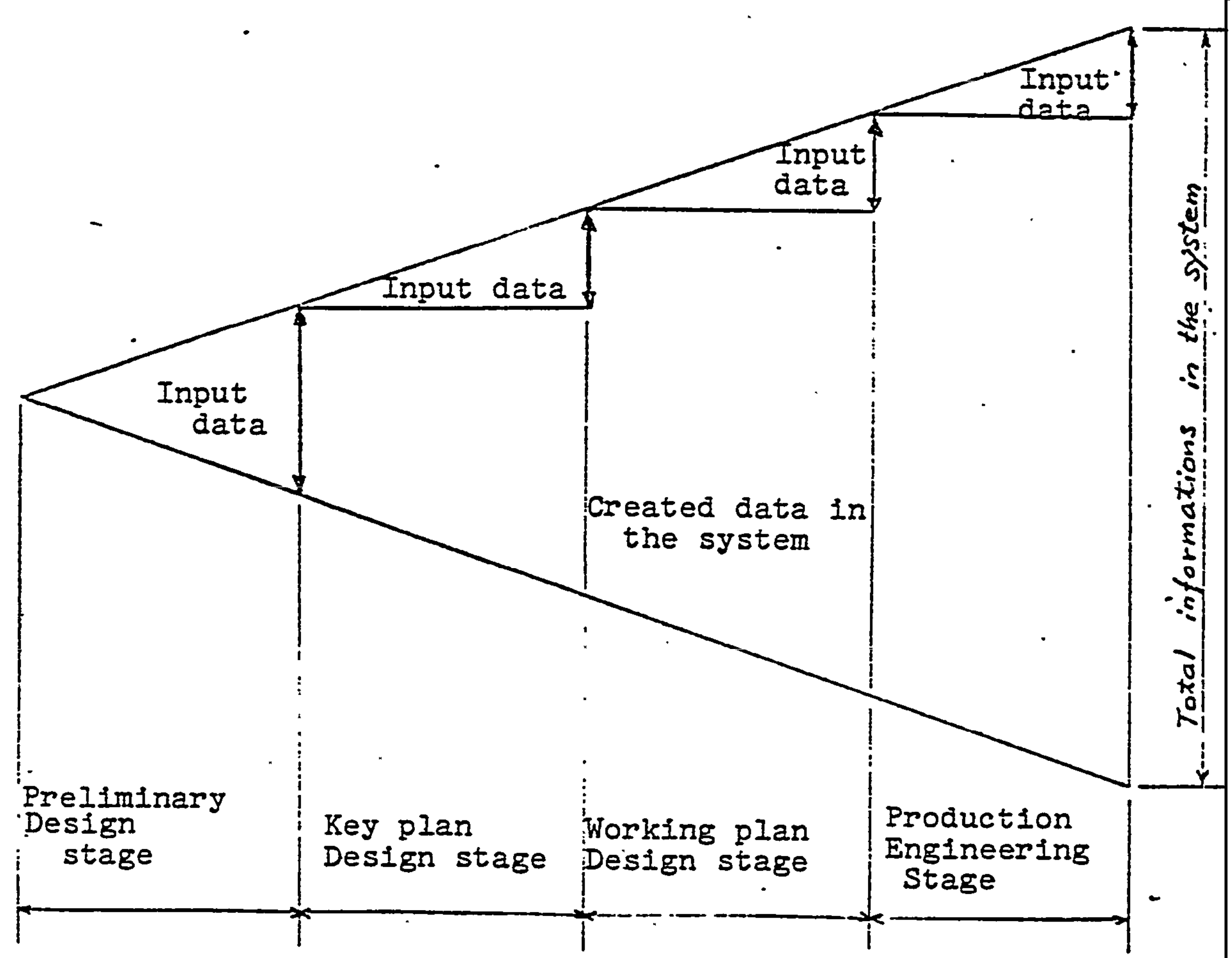
3. Scope of the System.

* Covers the detailed design and production engineering for hull.

* Excludes the functions of origination of design concept nor structural analysis.

* Maximum output from minimum input.

* Illustration of the proportion of the input required at each stage to the whole information in the system is shown in following figure.



4. Ships having been applied in IHI (as of May,1978)

| | |
|---|---|
| * 470,000 DWT | Tankers |
| * 250,000 DWT | Tankers |
| * 100,000-150,000 DWT | Tankers |
| * 15,000-100,000 DWT | Bulk carriers |
| * 20,000-100,000 DWT | Combination Carriers (Ore/Oil,Bulk/Oil) |
| * 20,000- 30,000 DWT | Containers |
| * 15,000- 30,000 DWT | cargos |

* Floating docks
* Platfrom-mounted pulp plant
* Large derric barge

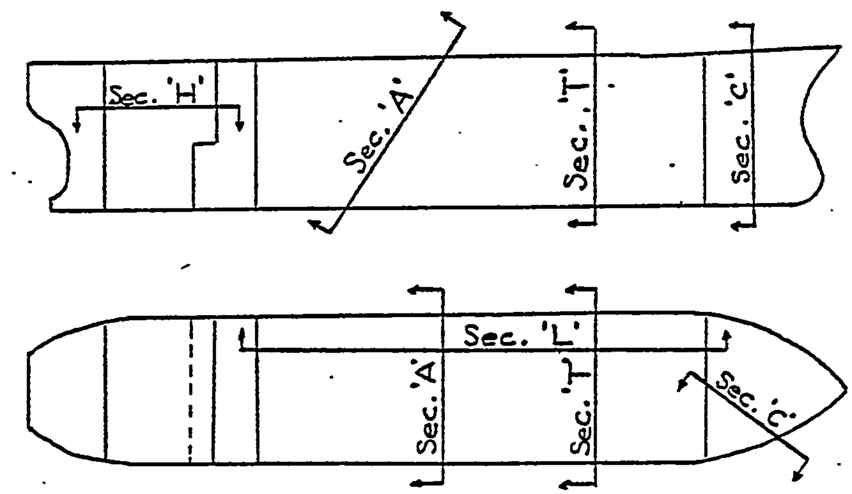
5. Specific Features of the System.

Specific features of IHICS are the following.

(A) System is based on data base concept.
System data base is under the control of
<u>IBM Information Management System (IMS).</u>

(B). 3-D Process and Functional Offset Data.
(Theree dimensional Process)

This technique allows to retrieve geometric data in any position and any section.




| | | |
|---|---|---|
| Transverse Sec. | Sec. 'T' | These section data can be obtained through 'Cut plane program.' |
| Horizontal Sec. | Sec. 'H' | |
| Longitudinal Sec. | Sec. 'L' | |
| Any other cut sec. | Sec.'A','C' | |

(C) "LINE" Statements.

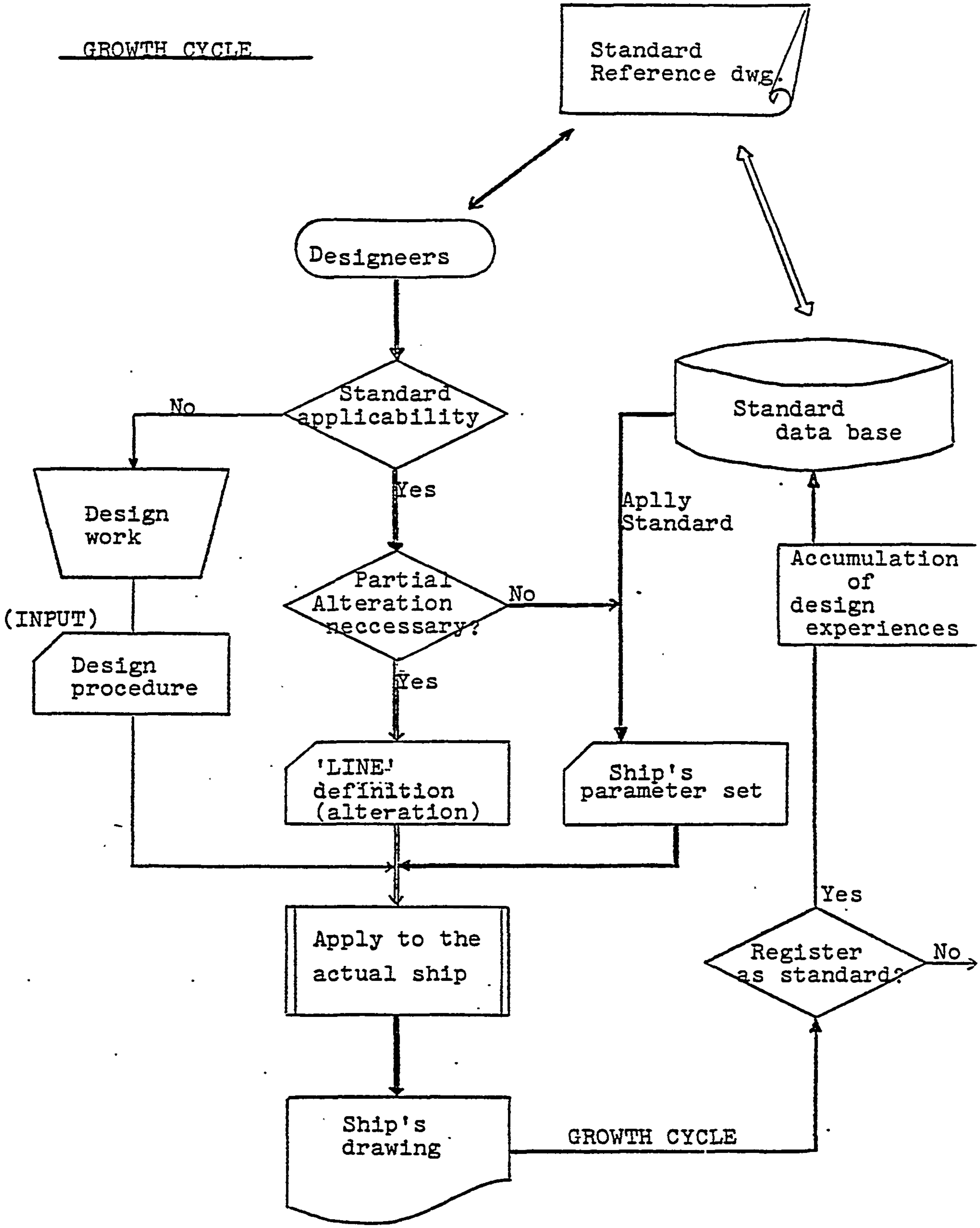
* "LINE" Statements (Language for IHI Numerical control Engineering) are developed for means of inter comunication between designers and the system.
* -Easy expression of ship's design figures and descriptions of design standard data are possible by use of these statements.

(D) Isolation of Technology and Accumulation of Standards.

* The system is isolated from design technology.
* The "STANDATD" is maintained by engineers followed by the progress of the design technology.
* These standards will be accumulated in the system and will grow towards a high technical design system with time in the same way as the accumulation of a designer's experiences would make him an expert.

STANDARD

- Shape standard:slot (Longitudinal cut out), hole, scallop Bracket, Stiffener
- Standard how to select/apply standards
- Fabrication standard excess, edge preparation


GROWTH CYCLE
Standard Reference dwg.
Designeers
Standard applicability
No
Yes
Design work
(INPUT)
Design procedure
Partial Alteration neccessary?
No
Yes
'LINE' definition (alteration)
Aplly Standard
Standard data base
Accumulation of design experiences
Ship's parameter set
Apply to the actual ship
Ship's drawing
GROWTH CYCLE
Register as standard?
Yes
No

(E) Relative expression of Data format

"LINE" is designed to describe objective figures to be designed in relative expression as far as possible so as to minimize corrections caused by the alteration of design.
This concept is coherent in all subsystems.

(F) Flexible operation

IHICS can be selected the most convenient usage of each subsystem againt the given circumstances such as ;

- Applied ship
  * Newly designed ship
  * Sister ship
  * Repaired or reconstructed ship
- Allowable designing period
- Computer Hardwares & Machinary for Fabrication

Typical selection can be seen in the following table.

2. Composition and usage of Subsystems

| case / Subsystem | A | B | C | D | Notes |
|---|---|---|---|---|---|
| Basic data creation subsystem | * | * | * | * | * Program language for applications : PL/I Optimizing compiler.<br>* Data base control : IMS DB/DC<br>* Required core size : 512KB |
| Section design Subsystem | | * | * | * | |
| Production engineering subsys. | * | * | * | * | |
| Data base control system | * | * | * | * | |
| D/C-I Character display | | | * | * | |
| D/C-II Graphic display | | | | * | |

(G) Online Capability (Option)

IHICS supports many online terminals under IMS/DB.DC capability.

6. Background of IHICS

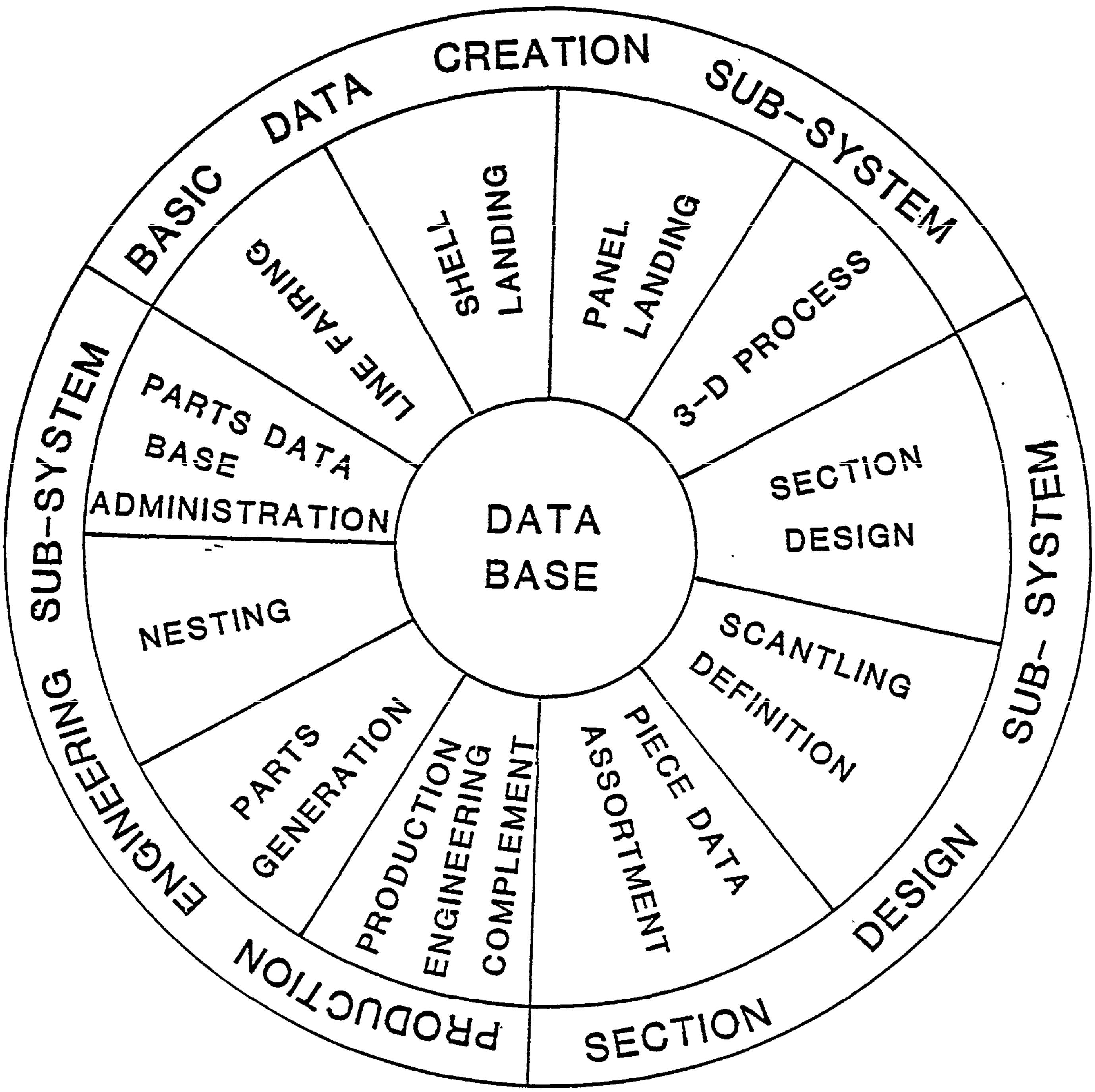
IHICS is based on the total hull design systems developed by IHI in 1971.
The new IHICS includes the suggestions obtained from the past ten year's experience.

IHICS PERSPECTIVE

IHICS is composed of the following three sub-systems:

* Basic Data Creation Sub-system
* Section Design Sub-system
* Production Engineering Sub-system

The system perspective and outline are shown in the following figure.



## BASIC DATA CREATION SUB SYSTEM

FAIRING OF A SHIP'S HULL

LINES FAIRING PROGRAM

:* SHELL LANDING PROGRAM

CONSISTS OF
- SEAM/BUTT LANDING PROGRAM
- LONGITUDINALS LANDING PROGRAM
- SCANTLING DEFINITION PROGRAM

* PANEL LANDING PROGRAM

CONSTSTS OF
- SEAM/BUTT LANDING PROGRAM
- LONGITUDINALS LANDING PROGRAM
- SCANTLING DEFINITION PROGRAM

* 3-D PROSESS PROGRAM

CONSTSTS OF
- PANEL DEFINITION PROGRAM
- COMPARTMENT DEFINITION PROGRAM
- CUT PLANE PROGRAM
- PANEL COMPOSITION PROGRAM.

...OUTPUT...

- GEOMETRY DATA BASE, PANEL DATA BASE, SCANTLING DATA BASE
- A COMPLETE DRAWING OF ANY DESIRED PORTION OF LINES DRAWING
- THE BOOK OF MOLD LOFT OFFSETS
- STRUCTURAL BODY PLAN(1/10, l/50)
- SHELL EXPANSION PLAN
- PANEL PLAN DECK/BULKHEAD/FLAT/......

## SECTION DESIGN SUB SYSTEM

* SECTION DESIGN PROGRAM

CONSISTS OF
- WEB'S FIGURE DEFINITION
- STIFFEMER & JOINT ARRANGEMENT ON A WEB

* SCANTLING DEFINITION PROGRAM

CONSISTS OF
- WEB/FACE PLATE SCANTLING DEFINITION PROGRAM
- STIFFENER SCANTLING DEFINITION PROGRAM

* PIECE DATA ASSORTMENT PROGRAM

CONSISTS OF
- PIECE DATA ASSORTMENT PROGRAM

...OUTPUT...

- SECTION PLAN(1/10, l/50)
- PIECE CONTROL DATA LIST
  - PRESENTS PIECE LISTS EACH ASSEMBLY UNIT.
  - INCLUDES PIECE NAME, QUANTITY, SCANTLING, WEIGHT, PIECE DWG FORMAT, FABRICATION PROCESS, AND OTHER PRODUCTION CONTROL DATA.
  - AFFORDS FACILITIES FOR DATA CORRECTION.

## PRODUCTION ENGINEERING SUB SYSTEM

* EDITTING PROGRAM

CONSISTS OF
- PART PROGRAM GENERATOR
- PLATE EDGE MODIFIER PROGRAM

* PART GENERATION PROGRAM

CONSTSTS OF
- SHELL PLATE DEVELOPMENT AND ASSEMBLING DATA CALCULATION (SHELL)
- LONGITUDINAL/TRANSVERSE FRAME DEVELOPMENT PROGRAM (LODACS)
- INTERNAL STRUCTURE DEVELOPMENT (LINE SYSTEM)
  (WEB PLATE, FACE PLATE, STIFFENERS AND OTHERS)

* NESTING PROGRAM

CONSISTS OF
- MANUAL NESTING PROGRAM
- INTERACTIVE NESTING PROGRAM BY CADS
- POST PROCESSOR FOR NUMERICAL CONTROL MACHINE

* PART DATA BASE ADMINISTRATIVE PROGRAM

CONSISTS OF
- PART DATA BASE HANDLER
- PIECE LIST EDITTING PROGRAM
  FOR FABRICATION
  SUB-ASSEMBLY
  ASSEMBLY
  ERECTION

... **OUTPUT** ...

.PIECE DRAWING (INCLUDING TABLE FORMAT)

.NUMERICAL CONTROL DATA/TAPE

.PIECE LIST FOR EACH STAGE

• TEMPLATE FOR BENDING (SHELL PLATE AND LONGITUDINAL FRAME)

.BLOCK MARKING DATA FOR SHELL

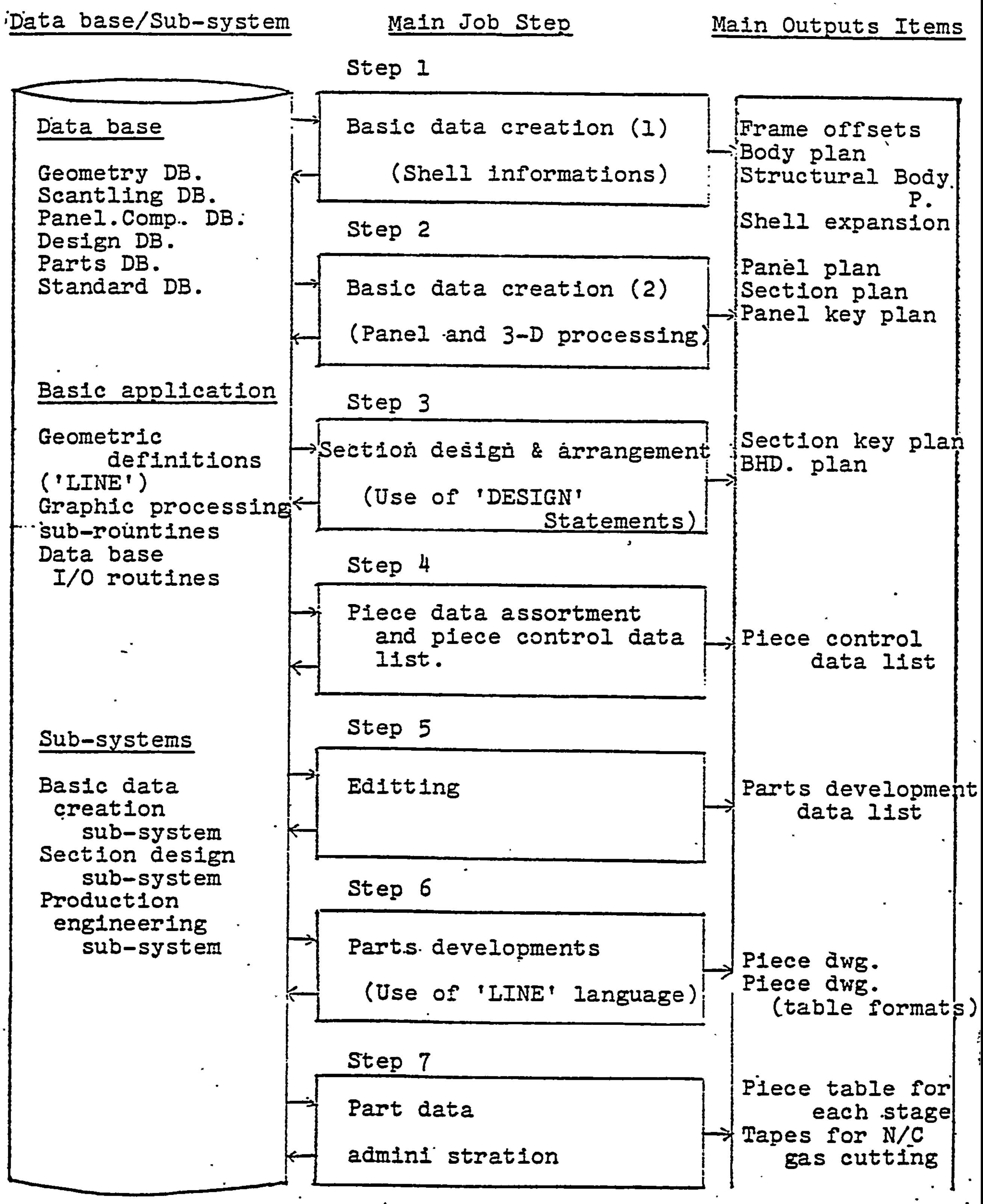
.JIG HEIGHT FOR ASSEMBLING CURVED SHELL BLOCK

'APPLICATION AREA '

| STAGE | ITEM. | PROGRAM | DATA BASE |
| --- | --- | --- | --- |
| PRELIMINARY DESIGN | GENERAL ARRANGEMENT & PLANNING<br>SCANTLING CALCULATION<br>LINES | | |
| DETAILED DESIGN | SHELL & PANEL LANDING<br>SECTION DESIGN<br>LOCAL SCANTLING CALCULATION<br>WORKING PLAN | | |
| PRODUCTION ENGINEERING | LINES FAIRING<br>PIECE LIST ISSUE<br>PARTS GENERATION<br>BLOCK ASSENMBLY<br>NESTING<br>N/C DATA | | |
| PRODUCTION CONTROL | SCHEDULING & OTHER PRODUCTION CONTROL | | |

## GENERAL SYSTEM OPERATION FLOW

The diagrammatic general system operation flow is shown in the following figure, in which main job steps, main output and main program modules are indicated.
The detaied explanations of each step are to be referred to the following sections.



# FUNCTIONS OF "LINE" STATEMENT

1. Objection for 'LINE' statements

   'LINE' statement is developed for common language of the geometric expression of hull form and structures.

   It is a kind of problem oriented language of which format is free.

2. Functions of 'LINE' statements

   (A) Geometric definitions

   Geometric expressions such as point, straight line, circle, tabcyl and thier composed line can be defined at any stage.

   The definition method adopts rather relative expression.

   (B) Auto-reference function to standard data

   (C) Contouring definition (Web plate definition)

   This gives contouring of figure (it is called as 'Motion'). Cutter location data of plates are created through this program.

   (D) Opening definition

   Man holes, drain holes, etc. are defined by this statement.

   (E) Plate edge information

   Edge preparation for welding and margin amount of material are indicated.

   (F) Data base reference

   Easy access to or reference to geometry, design and data base is available.

   (G) Marking line definition

   For the definiiion of marking line only (water line etc.)

(H) Stiffner development (Bracket, Flat bar, Inverted Angle) exact shape of a stiffener takitig account of **plate** thickness

- Precise shape at its both end.
- Bevel angle calculation.
- Calculation for many types of stiffeners(more than 400) are built in program.
- Any new type of stiffener can be easily registered.

(I) Face plate development.

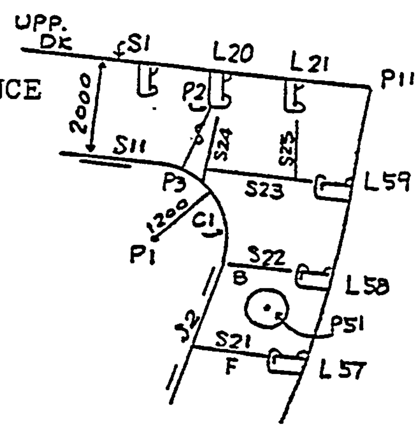
(J) Collar plates and others.

(K) Weight, Area, Marking length calculation.

Example expressions are shown in the next page.

## 3. An example of 'LINE' descriptions

(An example for corner part of transv. section)




Geometric Definition

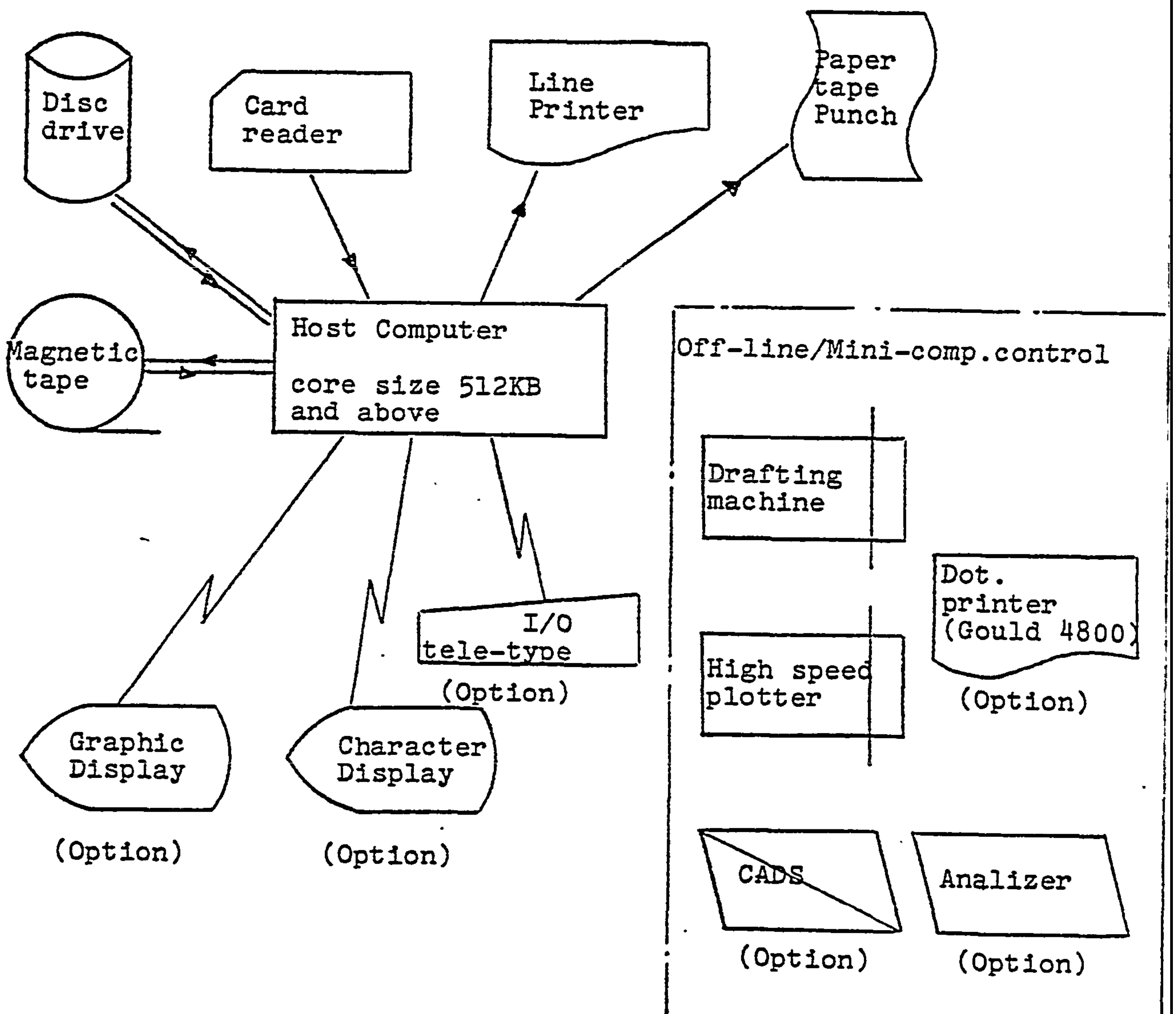
```
T       F60
     T1=F60----GEOMETRY DB REFERENCE
     PA1=PA-UD,ML---PANEL DB REFERENCE
     P11=OUT(SL,UD,1)----DESIGN DB REFERENCE
     S1=PA1,P11
     S11=PR-SL,L=2000,D
     LONG=SL,L40,L59   GEOMETRY,SCANTLING
     LONG=UD,L20,L21   DB REFERENCE
          ...
          ...
     C1=TD-S11,T1,-S2
     P1=CP-C1
     P2=SLOT-PC2,UD-L20
     S5=PT-P2,PT-P1
     P3=INT(S5-C1),U
     P4=ON-C1,FROM-P3,GL=150,D
     P5=UD-L20,TOP
     A1=P100,S11,C1,S2,-----------------COMPLEX SURFACE
     S24=PT-P4,PT-P5,SCS=UD-L20,ECS=A1
     S21=SL-L57,     SCS=SL-L57,ECS=A1
     S25=UD-L21,     SCS=UD-L21,ECS=S23
          ...
          ...

C    -----,T1,MSL(SL,L40,L59),T1,MSC(100),PA1,           } CONTOURING
            MSL(UD,L21,L21),PA1,MBS(S5,UD,L20,P3,21),C1 } DEFINITION
      ----- , &

H    MH(1,P51,150)                                ------ OPENING
                                                         DEFINITION

X    S21=F,FIT=A,PD=D,MRK=U,TYP+FC1S1,NAM=F15    }
X    S22=B,FIT=A,PD=D,MRK=U,TYP=BC1S1S1,NAM=B16  } PARTS EXPANSION
          ...
          ...

E                                           END OF PART PROGRAM
```

COMPOSITION OF AVAILABLE HARDWARES AND SUBSYSTEMS.

Required hardwares and subsystems for smooth operations of this system are as follows.

1. Available hardwares for this system

Facility of host computer should be determined taking any other system's applications into consideration.



APPENDIX B

IHICS - ACTUAL OUTPUT EXAMPLES

SYS.ENG.GRP.

# IHICS

## Actual Input/output Examples

IHI
ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES

OCT. 1978

Ishikawajima-Harima
Heavy industries Co., Ltd.
TOKYO JAPAN

REF. NO.

## LINE ---- Language for Parts Generation

```
*****                                                  *****
*****                                                  *****
*****  LINE DEFINITION  SECTION_1.          02/06/78   *****
*****                                                  *****

 INPUT_NO   DEFINITION

TITLE......T2715SL32          23                 W1        P160F      APFF23      1ER12TLE00050
    0001        C009 = IN(C009,R2)                                                IND00100
    0002        S014 = IN(S014,R2)                                                IND00150
    0003        C010 = IN(C010,R2)                                                IND00200
    0004        S005 = IN(S005,R1)                                                IND00250
    0005        C003 = IN(C003,R1)                                                IND00300
    0006        S006 = IN(S006,R1)                                                IND00350
    0007        S013 = IN(S013,R2)                                                IND00400
    0008        C004 = IN(C004,R1)                                                IND00450
    0009        LONG = SL   , F23      , L25       ,L318                          LNG00500
    0010        LONG = EF02, F23       , L6        ,L10                           LNG00550
    0011        T011 = F23                                                        AUX00650
    0012        PA11 = FF02                                                       AUX00700
    0013        S506 = PT-P(  7579.9, 10849.9), PT-P(  6579.2, 10096.0)           AUX00750
    0014        S509 = PT-P(  4555.9,  9081.2), PT-P(  5130.9,  9081.2)           JDI00800
    0015        S512 = PT-P(  5426.7,  4500.0), PT-P(  4023.0,  5038.8)           JDI00850
    0016        P150=INT(S509-S005)
    0017         P151=IN(S006,C004,R1)
    0018     S011 =SL-L300,ECS=S049,SCS=SL  -L300                                 STF00950
    0019     S022 =SL-L30,ECS=P300,SCS=SL  -L30
    0020     S023 =SL-L30A,ECS=S044,SCS=SL  -L30A                                 STF01050
    0021     P300=INT(S22-C3),0
    0022     S024 =SL-L30G,ECS=S050,SCS=SL  -L30G                                 STF01100
    0023     S025 =SL-L31,ECS=S026,SCS=SL  -L31                                   STF01150
    0024     S030 =EF02-L10,ECS=S027,SCS=EF02-L10                                 STF01300
    0025     S039 =SL-L308,ECS=A11,SCS=SL  -L308                                  STF01450
    0026     S041 =SL-L29,ECS=A11,SCS=SL  -L29                                    STF01500
    0027        S044=PR-S(CL),L=5100,0,SCS=S039,ECS=S022
    0028     S046 =SL-L30E,ECS=S009,SCS=SL  -L30E
    0029        S049=PR-S(CL),L=5100,0,SCS=S054,ECS=S039
    0030     S050 =FF02-L8,L=0,0,SCS=S055 ,ECS=S102                               STF01700
    0031     S021=IN(S014,R2,P)                                                   STF01750
    0032     C022=IN(C010,R2,P)                                                   STF02200
    0033     S010=IN(S005,R1,P)                                                   STF02300
    0034     S017=IN(S012,R2,P)                                                   STF02350
    0035     P030=SLOT-PC2(1),EF02-L9                                             STF02400
    0036     PA02=EF02                                                            STF02500
    0037     S003=EF02-L8,L=0,0                                                   STF02550
    0038     C020=IN(C009,R2,P)                                                   STF02600
    0039       P504 =   5731.0, 10334.9                                           STF02700
    0040       P505 =   3194.2,  3039.7                                           STF02750
    0041     P023=INT(S049 -S039 )                                                STF02150
    0042     S009 =PR-S021,L=15,0,SCS=S100 ,ECS=S011                              STF00900
    0043     P025=INT(S009 -S011 )                                                STF02000
    0044     S004=PA02,S003                                                       STF02250
    0045     S054 =PT-P(CP-C022),PR-S004,SCS=S010,ECS=S017                        STF02050
    0046     P031=CP-C020                                                         STF02450
    0047     S055 =PT-P030,PT-P031,SCS=P030,ECS=A11                               STF02100
    0048     P033=ON-S024 ,FROM-P(INT(S024 -S050 )),GL=550,0                      STF01800
    0049     S026 =PT-P(EF02-L9,ST),PT-P033,SCS=EF02-L9,ECS=S024                  STF01200
    0050     P032=ON-S026 ,FROM-P(INT(S025 -S026 )),GL=350,0                      STF01850
    0051     S027 =PT-P(SL-L31A,ST),PT-P032,SCS=SL-L31A,ECS=S026                  STF01250
    0052     S100=EQ-S050                                                            02601
    0053     S101=EQ-S009                                                            02602
```

Geometric definition

Example of partprogram generated by an editting program in Design-subsystem.

Element surface of a Web figure (Retrieved from the Design-DB) — INPUT_NO 0001–0008

Longitudinal data retrieved — INPUT_NO 0009–0010

Frame-line retrieved (curved line) — INPUT_NO 0011

Inner-panel data at the section retrieved — INPUT_NO 0012

P*** ---- Point definition

S*** ---- Straight line definition

C*** ---- Circle definition

PA** ---- Inner panel surface definition

T*** ---- curved line definition

A*** ---- Grouped surface definition

```
0054      S107=SQ-S046                                                     02603
0055          A11=P150,S005,C003,S006,P151
0056      P034=INT(S044 -S022 )                                         STF01900
0057      S033 =PT-P034,PP-S022 ,SCS=S022 ,ECS=S041                     STF01350
0058      P024=ON-S039 ,FROM-P023,GL=500,0                              STF01950
0059      S039 =PT-P024,PT-P025,SCS=S011 ,ECS=S039                      STF01400
0060     S333=PR-S(CL),L=5100,0,SCS=S509,ECS=S22
0061     S336=PR-S333,L=545,0
0062     S334=SL-L305,SCS=S333,ECS=S336

********** STEP WAS EXECUTED - COND CODE 0000
```

3

```
0040   P99?   104          0041   P033   502
0041   P995     3          0042   S026     2
0042   P995   104          0043   P032   502
0043   P995     3          0044   S027     2
0045   S100   444          0046   S101   444
0047   S102   444          0048   A011   200
0049   P034   104          0050   S033     4
0051   P024   502          0052   S038     2
0052   S?95   303          0052   S333   102
0052   S336   102          0052   S334   202

********** STEP WAS EXECUTED - COND CODE 0000

 C                                                        MTN02800
  T011, MSL( SL   , L29      , L31A     ,10),   T011,     MTN02850
     MSC(100),                                            MTN02900
  PA11, MSL( EF02, L10       , L10      ,10),   PA11,     MTN02950
  MBS( S506, EF02, L9        , P507, 12 ),                MTN03000
  C009,SC14,C010,                                         MTN03050
  S509,                                                   MTN03100
  S005,C003,S006,                                         MTN03150
  S512,                                                   MTN03200
  &                                                       MTN03250
UNDEFINED       SYMBOL=(P507)YYYYY UNDECK
```

Contouring definition of a web plate

```
  G    FC11=A11,TYP=T,SCN= 300.0*25.0                     GEX03300
  X  S022  =F,TYP=FC1S1,PD=U,NAM=3*           ,MRK=D,FIT=A   EXP03450
```

Face plate definition used for stiffeners' development

Stiffener (flat bar) definition

```
***** EXPANSION SURFACE (S022) *************************************
*    SCS=SL-L30           ECS=P300                                  *
*    SCS_ANGLE=  67.4     ECS_ANGLE=  90.0    EXP_ANGLE=  79.7      *
*    SCS_THETA=  90.9     ECS_THETA=  90.0    STR_THETA=   0.0      *
*    E_XS=   5.4686       E_YS=    5.7359                           *
*    E_XE=   4.4562       E_YE=    6.1746                           *
*    SYMS(1)=S  INDXS(1)=246  SYMS(2)=L   INDXS(2)=  6              *
*    SYME(1)=S  INDXE(1)=247  SYME(2)=    INDXE(2)=  0              *
*    SCS_PLANE=      0.3815      -0.8427      0.3799     -4.8565    *
*    ECS_PLANE=      0.0000       0.9336     -0.3584     -1.9304    *
*    EXP_PLANE=      0.1790      -0.3526     -0.9185      3.7772    *
*    SCANTLING=    150.0    12.5     0.0     0.0     0.0            *
*    LENGTH=        1.0844                                          *
*    WEIGHT=       13.9523                                          *
*    EXP_NAME= F2                                                   *
********************************************************************
```

Results of a stiffener above defined

```
 X  S039  =B,TYP=BC2C6F1,PD=U,NAM=12Y/B1.F1          ,MRK=D       ,EXP03900
    FIT=A,DATA(C=150,R=300)                                        EXP03950
```

Stiffener (bracket) definition
[ Bracket development built in program ]

```
--- SKT CL_DATA COUNT =     33
```

Results of a stiffener above defined

```
  0.0000     0.0000  20001.0000    1.5821    0.0000  20002.0000    1.5821   -0.1269  20011.0000   0.5396
 -0.4457 30012.0?0? 405000.0?00    0.6273   -0.7326      0.2999    0.3361   -0.6605  20013.0000   0.3226
```

```
    -0.6670  20004.0000   0.0233   -0.0492 402200.0000 406000.0000   0.0149   0.0000   0.0499   0.0649
     0.0000 402210.0000  999.0000  -0.0492 402200.0000 406000.0000   0.0149   0.0000   0.0499   0.0649

--- BKT MK_DATA COUNT =    13

 405000.0000   0.2846  -0.5080 405100.0000   1.5471  -0.1220 405000.0000 404100.0000   0.9541  -0.2533
      0.9158  -0.2650  999.0000 405100.0000  1.5471  -0.1220 405000.0000 404100.0000   0.9541  -0.2533

--- BKT CH_DATA COUNT =     1

F1

   ------ CL_DATA STORE END -----
   ------ MK_DATA STORE END -----
   ------ OP_DATA STORE END -----
   ------ VI_DATA STORE END -----
   ------ CH_DATA STORE END -----

***** EXPANSION SURFACE (S039) ************************************
*   SCS=SL-L308         ECS=A11                                   *
*   SCS_ANGLE=  64.2    ECS_ANGLE=  90.0   EXP_ANGLE=  90.0       *
*   SCS_THETA=  89.2    ECS_THETA=  86.9   STR_THETA=   0.0       *
*   E_XS=    6.1358     E_YS=    7.1020                           *
*   E_XE=    4.5560     E_YE=    7.1876                           *
*   SYMS(1)=S  INDXS(1)=246  SYMS(2)=L  INDXS(2)=  8              *
*   SYME(1)=S  INDXE(1)=  2  SYME(2)=F  INDXE(2)=  1              *
*   SCS_PLANE=    0.4354    -0.8981     0.0623    -3.2476         *
*   ECS_PLANE=    0.0000     1.0000     0.0000    -4.5560         *
*   EXP_PLANE=    0.0000    -0.0541    -0.9985     7.4235         *
*   SCANTLING=   12.5   100.0   11.0    0.0    0.0                *
*   LENGTH=         1.5821                                        *
*   WEIGHT=        50.8340                                        *
*   EXP_NAME= Y2          B1          F1                          *
*******************************************************************

X  S041   =B,TYP=BC2C6F1,PD=U,NAM=13Y/B1.F1          ,MRK=D    ,EXP04030
     FIT=A,DATA(C=150,R=300)                                    EXP04050
```

Stiffener development
* parts generation
  - graphical data and dimension
  - store results into DB
* edge preparation (Bevel & excess)
* consideration of plate thickness
* marking data of a stiffener for the web :
  - marking location
  - direction of plate thickness
  - fitting angle against the web.

Bracket with a flat bar definition

additional data

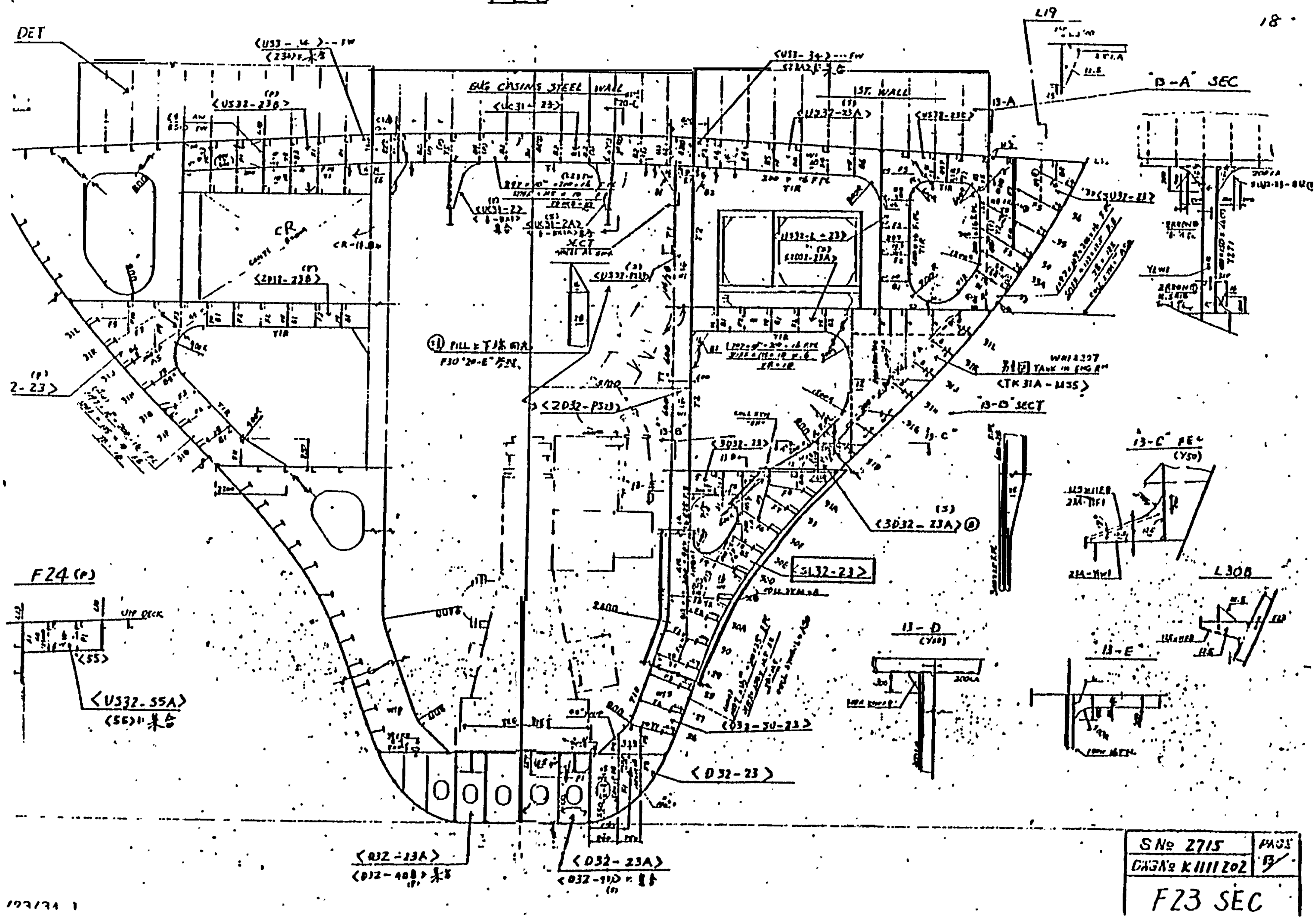
```
--- BKT CL_DATA COUNT =    33

     0.0000     0.0000  20001.0000   1.1209    0.0000  20002.0000   1.1206  -0.1289  20011.0000   0.4406
    -0.3367  30012.0000 406000.0000  0.5283   -0.6236    0.2999     0.2365  -0.5542  20013.0000   0.2226
    -0.5597  20004.0000   0.0197   -0.0497 402200.0000 406000.0000  0.0149   0.0000   0.0499   0.0649
     0.0000 402210.0000  999.0000  -0.0497 402200.0000 406000.0000  0.0149   0.0000   0.0499   0.0649

--- BKT MK_DATA COUNT =    13

 405000.0000   0.1952  -0.3961 405100.0000   1.0856  -0.1239 405000.0000 404100.0000   0.6786  -0.1983
      0.6404  -0.2100  999.0000 405100.0000  1.0856  -0.1239 405000.0000 404100.0000   0.6786  -0.1983
```

| SNO | BLOCK | PA_SUB | DATE |
|---|---|---|---|
| 2715 | SL22 | | 78/06/02 |

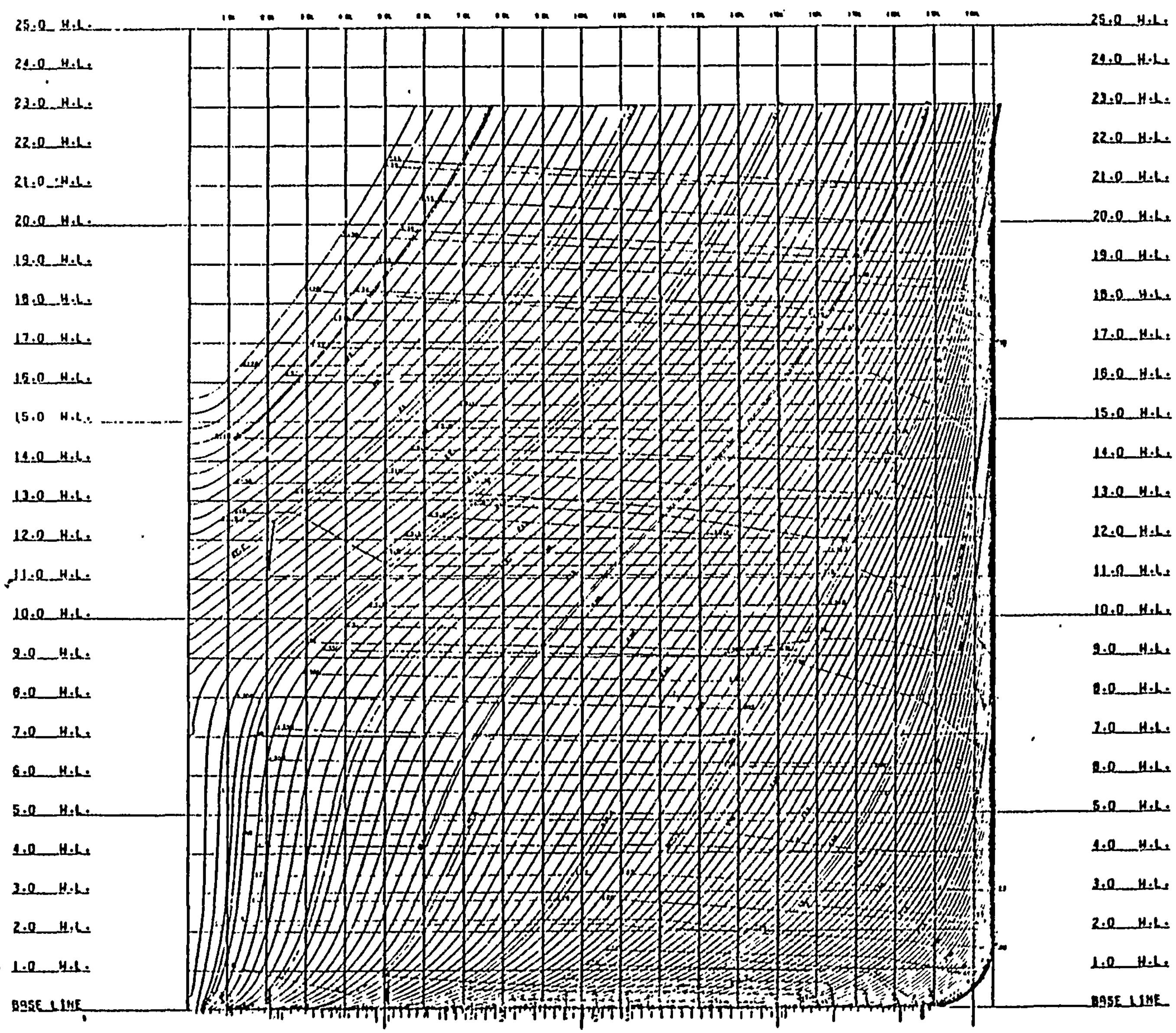
Processed parts list for summary

| SUB | PA_SUB | PIECE | LENGTH | CUT_LNG | MRK_LNG | WEIGHT | ER_COD | SURFAC |
|---|---|---|---|---|---|---|---|---|
| 23 | | F2 | 1.0844 | 0.000 | 0.000 | 13.9 | | S022 |
| 23 | Y2 | B1 | 1.5821 | 3.878 | 1.320 | 50.8 | | S039 |
| 23 | Y2 | F1 | 1.3202 | 0.000 | 0.000 | 11.4 | | S039 |
| 23 | Y1 | B1 | 1.1209 | 2.908 | 0.931 | 30.3 | | S041 |
| 23 | Y1 | F1 | 0.9311 | 0.000 | 0.000 | 8.0 | | S041 |
| 23 | | F11 | 0.7508 | 0.000 | 0.000 | 9.3 | | S033 |
| 23 | | B12 | 0.0000 | 0.000 | 0.000 | 0.0 | | S044 |
| 23 | | F3 | 0.6822 | 0.000 | 0.000 | 8.0 | | S023 |
| 23 | | A14 | 1.9105 | 0.000 | 0.000 | 60.4 | | S049 |
| 23 | | F4 | 1.6884 | 0.000 | 0.000 | 24.2 | | S011 |
| 23 | | F13 | 1.1400 | 0.000 | 0.000 | 13.6 | | S038 |
| 23 | | F16 | 1.5198 | 0.000 | 0.000 | 30.7 | | S009 |
| 23 | | A15 | 1.3428 | 0.000 | 0.000 | 30.9 | | S050 |
| 23 | | F6 | 0.9827 | 0.000 | 0.000 | 12.4 | | S024 |
| 23 | | B5 | 0.8080 | 2.286 | 0.000 | 22.2 | | S046 |
| 23 | | F9 | 1.3062 | 0.000 | 0.000 | 17.6 | | S026 |
| 23 | | F7 | 0.7938 | 0.000 | 0.000 | 9.6 | | S025 |
| 23 | | F8 | 1.1156 | 0.000 | 0.000 | 14.3 | | S027 |
| 23 | | B10 | 0.3243 | 1.092 | 0.000 | 5.8 | | S030 |
| 23 | | F18 | 3.2304 | 0.000 | 0.000 | 277.0 | | S333 |
| 23 | | B17 | 0.4850 | 1.664 | 0.000 | 12.2 | | S334 |
| 23 | | W1 | 0.0000 | 29.123 | 45.103 | 1467.6 | | |

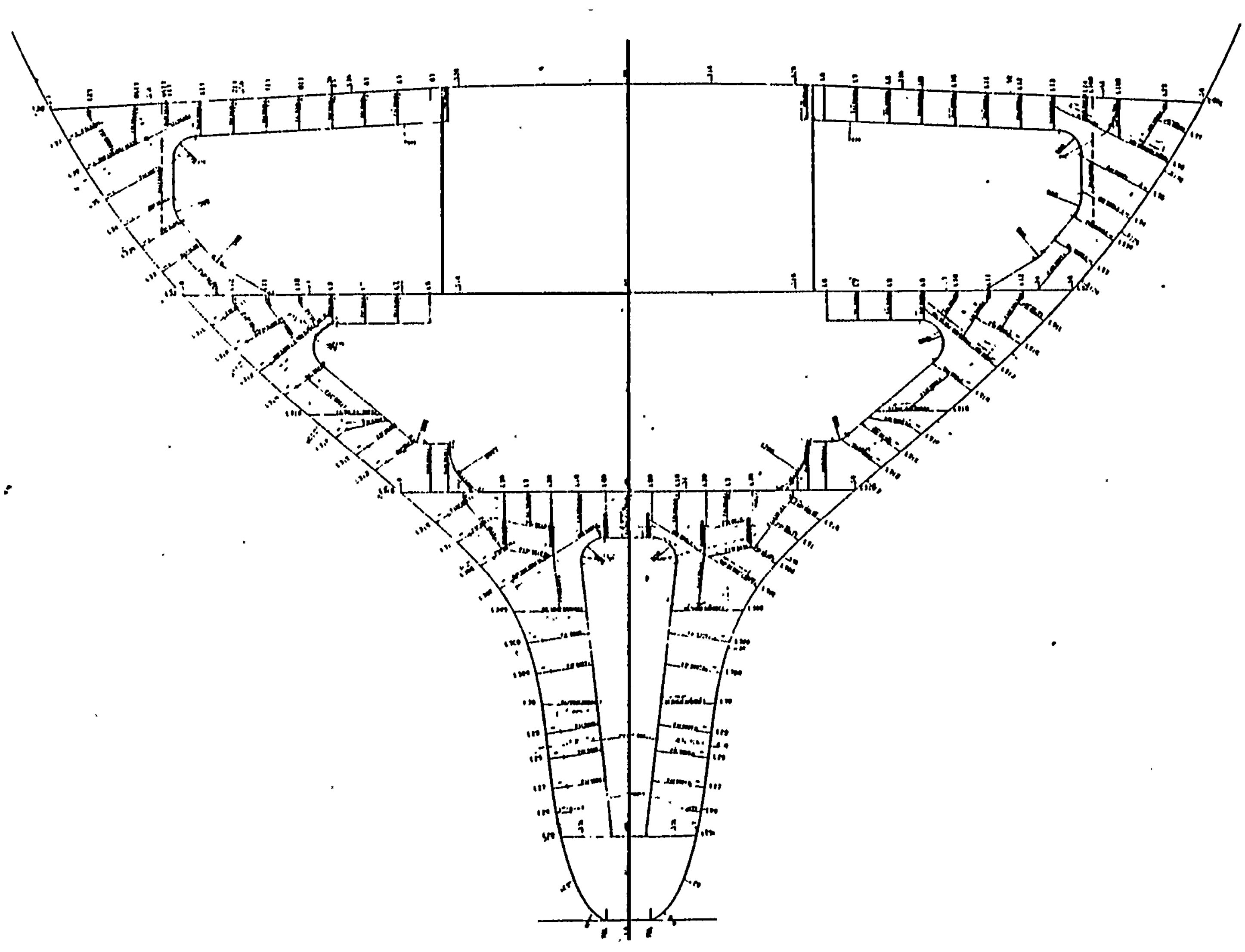
F23


18
DET
ENG CASING STEEL WALL
ST. WALL
CR
"B-A" SEC
"B-D" SECT
B-C
B-D
B-E
L19
L30B
<TK 31A - M35>
<2D32-P523>
<3D32-23>
<3D32-23A>
<SL32-23>
<D32-SU-23>
<D32-23>
<D32-23A>
<US32-23B>
<US32-23A>
<UC31-23>
<2D32-23B>
F24 (P)
UP DECK
<55>
<US32-55A>
S№ 2715
DWG№ K1111202
F23 SEC

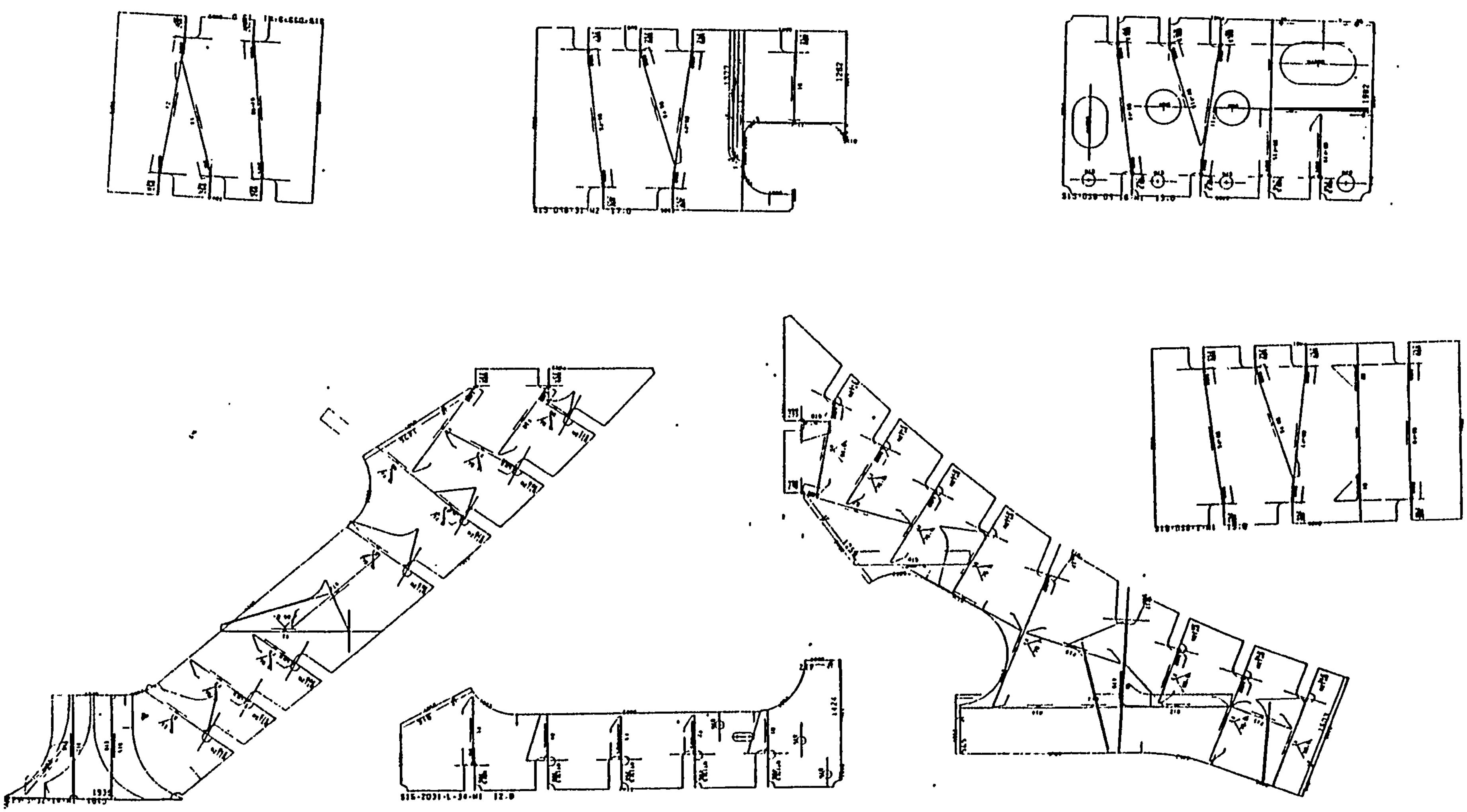
# STRUCTURAL BODY PLAN

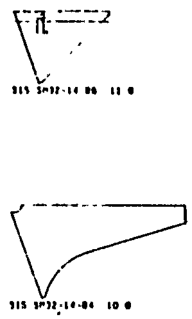


# SECTION DRAWING

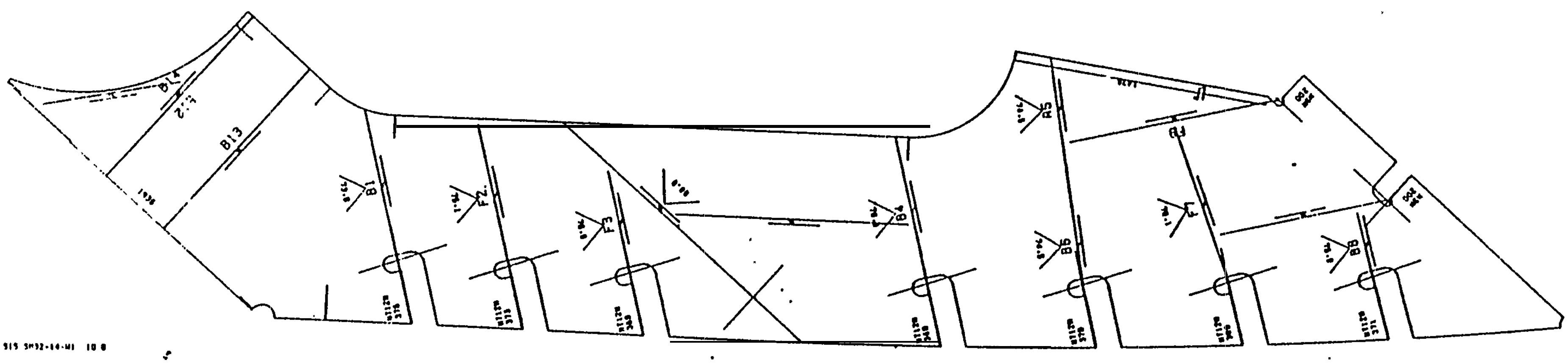


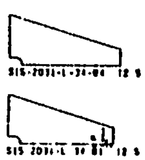
# DRWING FOR SUB-ASSEMBLY

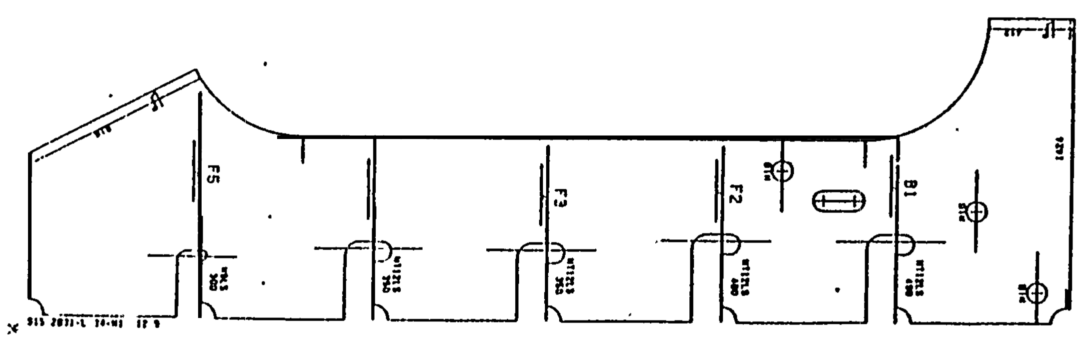




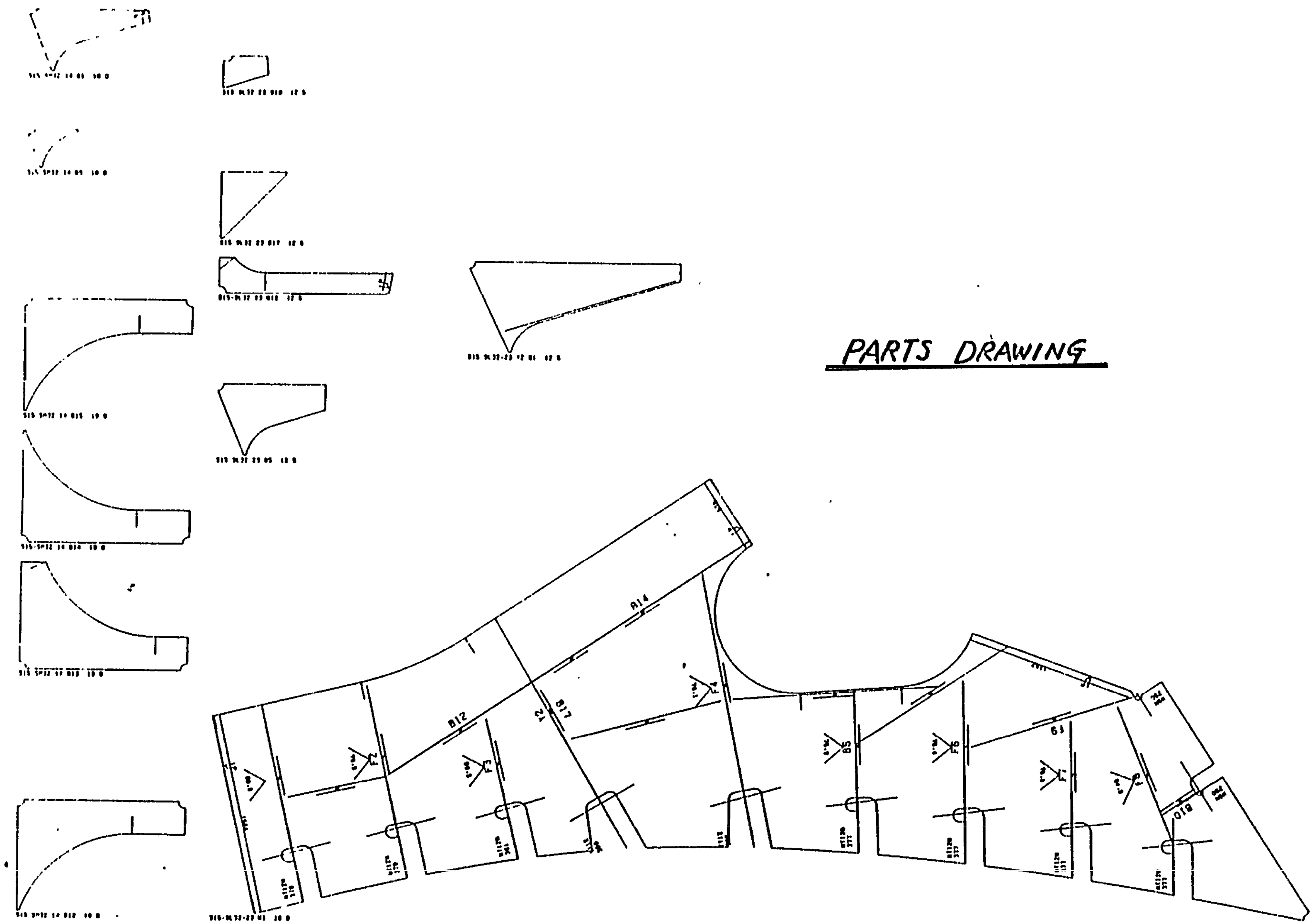
# PARTS DRAWING







## PARTS DRAWING

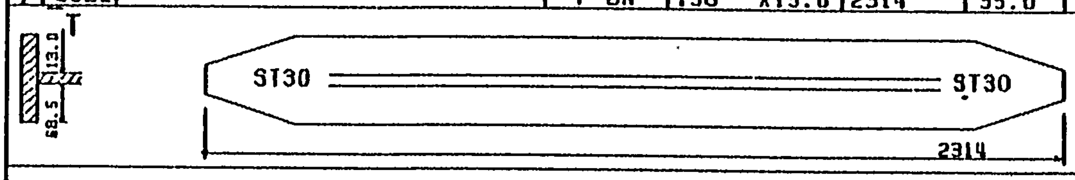


| SHIP NO | PANEL | SCANTLING | FAB.SHOP |
|---|---|---|---|
| 2715 | DS | 150 ×13.0 | |

# FACE PLATE

DATE 78. 5 .29 PAGE 1

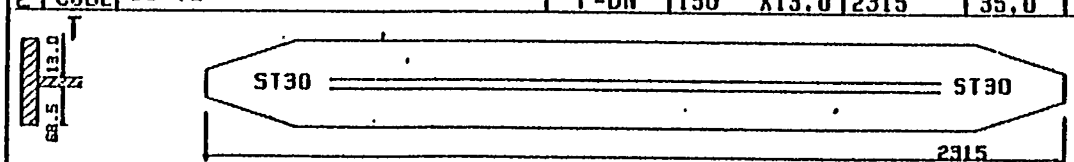
| NO | PART CODE | | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|
| 1 | | DS-T1 | P-DN | 150 X13.0 | 2314 | 35.0 | 1157 | |




(OT)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 1 | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 1 | | | | | | | | | | | | | | |

| NO | PART CODE | | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|
| 2 | | DS-T2 | P-DN | 150 X13.0 | 2315 | 35.0 | 1158 | |




(OT)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 1 | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 1 | | | | | | | | | | | | | | |

TOTAL WEIGHT 0.0 TOTAL LENGTH 0.0 PANEL DS

25

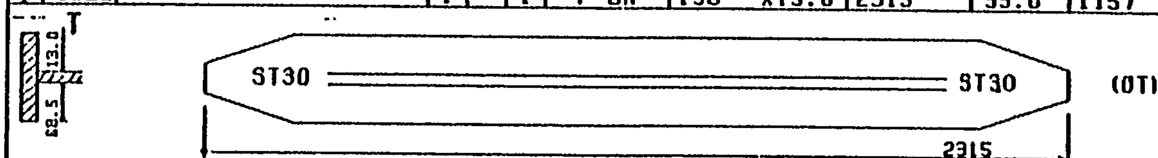
| SHIP NO | BLOCK | SCANTLING | FAB.SHOP |
|---|---|---|---|
| 2715 | DS6 | 150 × 13.0 | |

# FACE PLATE

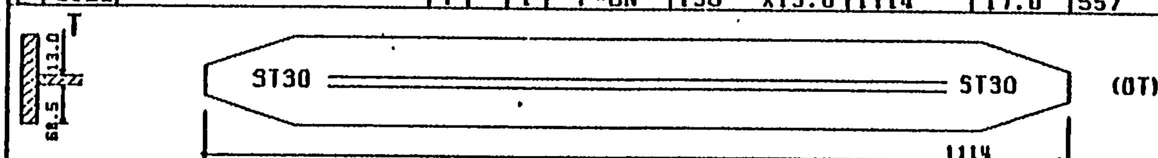
DATE 78. 5 .23

PAGE 1

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | -2-T1 | 1 | | 1 | P-ON | 150 X13.0 | 2315 | 35.0 | 1157 | |




| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | -3-T1 | 1 | | 1 | P-ON | 150 X13.0 | 1114 | 17.0 | 557 | |




| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | |

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | M.LENGTH | WEIGHT | C.OF G | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | | | | |

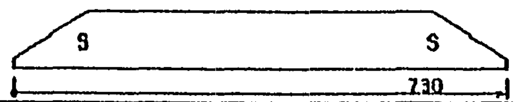
26

| SHIP NO | PANEL | SCANTLING | FAB. SHOP |
|---|---|---|---|
| 2715 | DS | 75 X 13.0 | |

# FLAT BAR

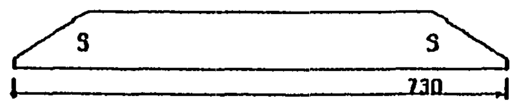
PAGE 1

DATE 78. 5 .23 NOTES

| NO | PART CODE | SHOWN | | |
|---|---|---|---|---|
| 1 | DS-F14 | P-UP |  | (FH) |

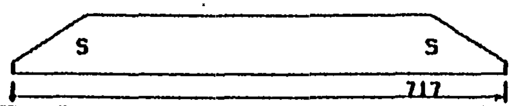


| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 39 | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 39 | | | | | | | | | | | | | | |

| NO | PART CODE | SHOWN | | |
|---|---|---|---|---|
| 2 | DS-F14A×S | P-UP |  | (FH) |



| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 3 | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 3 | | | | | | | | | | | | | | |

| NO | PART CODE | SHOWN | | |
|---|---|---|---|---|
| 3 | DS-F14B×S | P-UP. |  | (FH) |

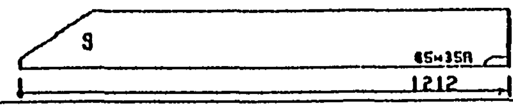


| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 1 | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 1 | | | | | | | | | | | | | | |

TOTAL WEIGHT 0.0 TOTAL LENGTH 0.0 PANEL DS

| SHIP NO. | BLOCK | SCANTLING | FAB. SHOP | FLAT BAR | | PAGE |
|---|---|---|---|---|---|---|
| 2715 | DS6 | 150 X13.0 | | | | 1 |

DATE 70. 5 .23

| NO | PART CODE | P | C | S | | NOTES |
|---|---|---|---|---|---|---|
| 1 | -94-F1 | 1 | | 1 |  (UP) | |
| | | SHOWN | | | | |
| | | S-UT | | | | |
| NO | PART CODE | P | C | S | | |
| 2 | | | | | | |
| | | SHOWN | | | | |
| NO | PART CODE | P | C | S | | |
| 3 | | | | | | |
| | | SHOWN | | | | |
| NO | PART CODE | P | C | S | | |
| 4 | | | | | | |
| | | SHOWN | | | | |
| NO | PART CODE | P | C | S | | |
| 5 | | | | | | |
| | | SHOWN | | | | |
| NO | PART CODE | P | C | S | | |
| 6 | | | | | | |
| | | SHOWN | | | | |

TOTAL WEIGHT 32.0 TOTAL LENGTH 2424.0 BLOCK DS6

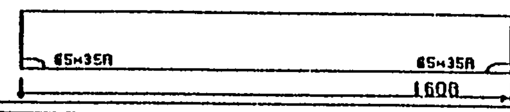
| SHIP NO | PANEL | SCANTLING | FAB. SHOP |
|---|---|---|---|
| 2715 | DS | 150 X 13.0 | |

# FLAT BAR

PAGE 1

DATE 78. 5 .23 NOTES

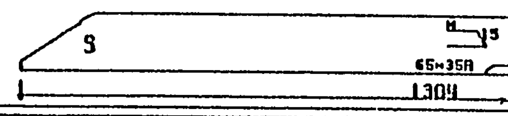
| NO | PART CODE | SHOWN |
|---|---|---|
| 1 | DS-F1 | S-0T |




(UP)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 16 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 16 | | | | | | | | | | | | | | | |

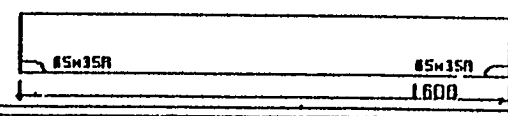
| NO | PART CODE | SHOWN |
|---|---|---|
| 2 | DS-F2 | S-0T |




(UP)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 16 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 16 | | | | | | | | | | | | | | | |

| NO | PART CODE | SHOWN |
|---|---|---|
| 3 | DS-F3 | S-0T |




(UP)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 16 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 16 | | | | | | | | | | | | | | | |

TOTAL WEIGHT 0.0 TOTAL LENGTH 0.0 PANEL DS

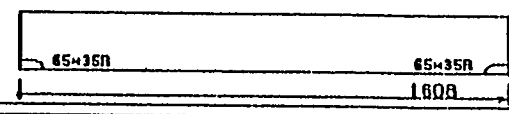
| SHIP NO | PANEL | SCANTLING | FAB. SHOP |
|---|---|---|---|
| 2715 | DS | 200 X13.0 | |

# FLAT BAR

PAGE 1

DATE 78. 5 .23 NOTES

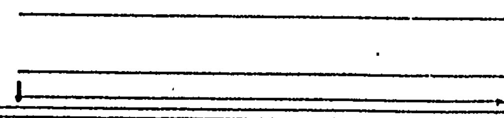
| NO | PART CODE | SHOWN |
|---|---|---|
| 1 | DS-F5 | S-0T |




(UP)

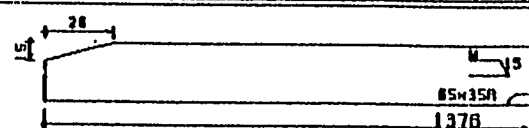
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 5 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 5 | | | | | | | | | | | | | | | |

| NO | PART CODE | SHOWN |
|---|---|---|
| 2 | DS-F6 | |



| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 4 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 4 | | | | | | | | | | | | | | | |

| NO | PART CODE | SHOWN |
|---|---|---|
| 3 | DS-F6A | S-0T |




(UP)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13A | 13F | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | | | 1 | | | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | | | | | | | | | |
| S | | | | | | 1 | | | | | | | | | | | | | | | |

TOTAL WEIGHT 0.0 TOTAL LENGTH 0.0 PANEL DS

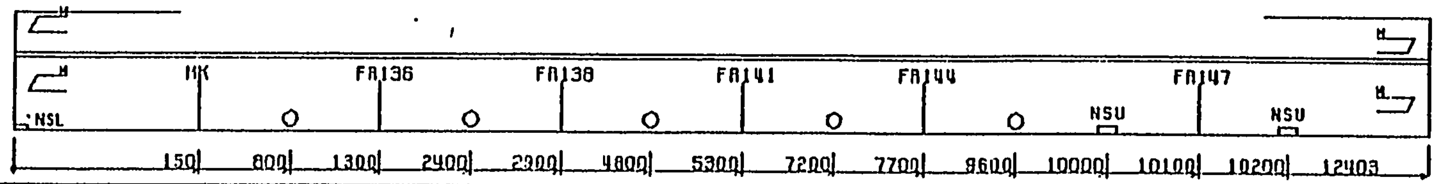
30

SHIP NO 2715 BLOCK DSG FAB. SHOP

# ANGLE

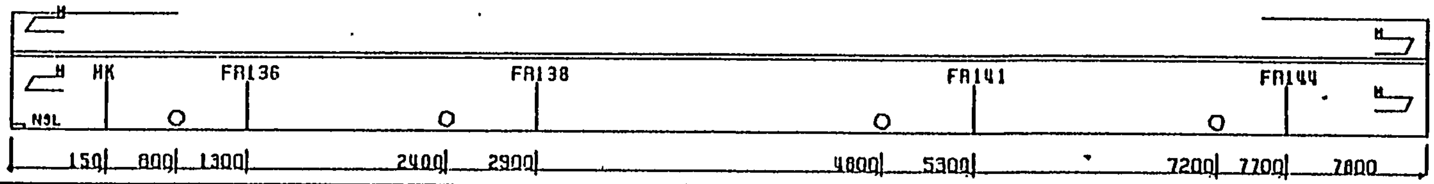
DATE 78. 5 .23 PAGE 1

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CODE | -AL1 | 8 | | 8 | S-IN | 250 X 90 X10 / 15 | P35 | AM | | 360.0 | | FW N+3 |



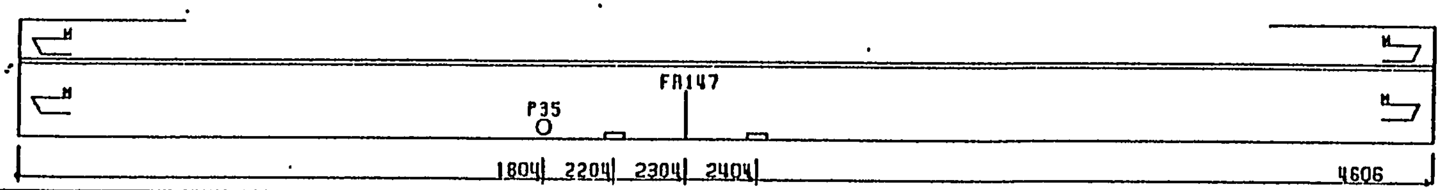

(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | CODE | -AL2 | 1 | | 1 | S-IN | 250 X 90 X10 / 15 | P35 | AM | | 226.0 | |



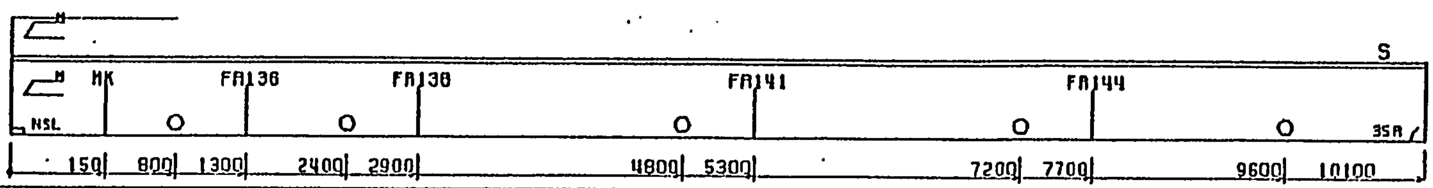

(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | CODE | -AL3 | 1 | | 1 | S-IN | 250 X 90 X10 / 15 | NSU | AM | | 133.0 | |




(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | CODE | -AL4 | 1 | | 1 | S-IN | 250 X 90 X10 / 15 | P35 | AM | | 293.0 | |




(FW)

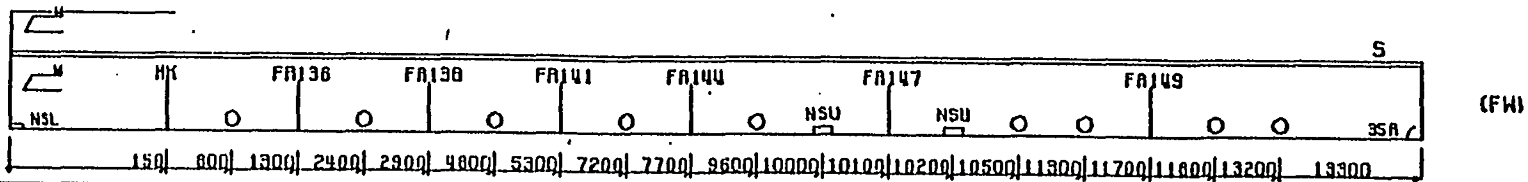
TOTAL WEIGHT 7064.0 TOTAL LENGTH 243459.! BLOCK DS6

SHIP NO 2715 BLOCK DS6 FAB. SHOP

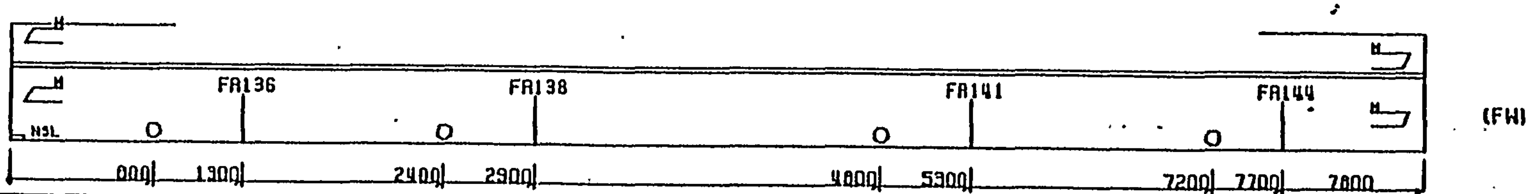
# ANGLE

DATE 78. 5 .23 PAGE 2

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -AL5 | | 1 | | 1 | S-IN | 250 X 90 X10 / 15 | P35 | AM | | 386.0 | |




| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -AL7 | | 3 | | 3 | S-IN | 250 X 90 X10 / 15 | P35 | AM | | 226.0 | |




| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | | |

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | | | | | |

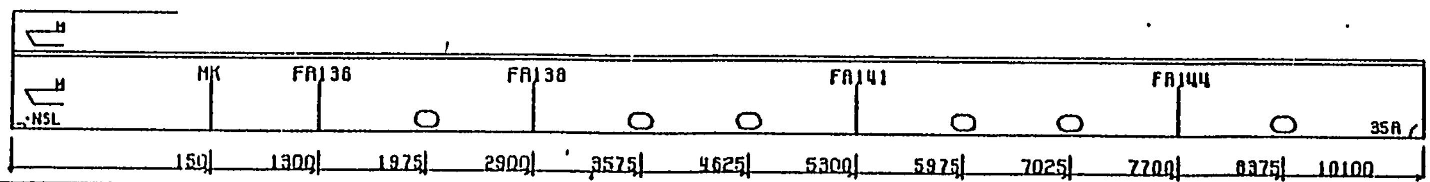
TOTAL WEIGHT 2128.0 TOTAL LENGTH 73400.1 BLOCK DS6

| SHIP NO | BLOCK | FAB. SHOP |
|---|---|---|
| 2715 | DS6 | |

# ANGLE

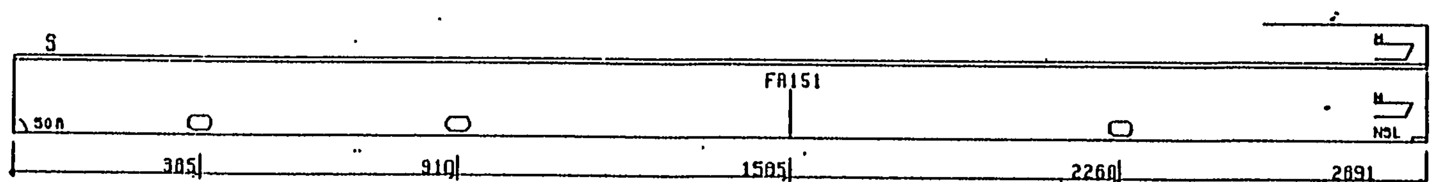
DATE 78. 5 .23 PAGE 1

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | -S-AL2 | 1 | | 1 | P-IN | 250 X 90 X12 / 16 | DA3L | AM | | 336.0 | | |



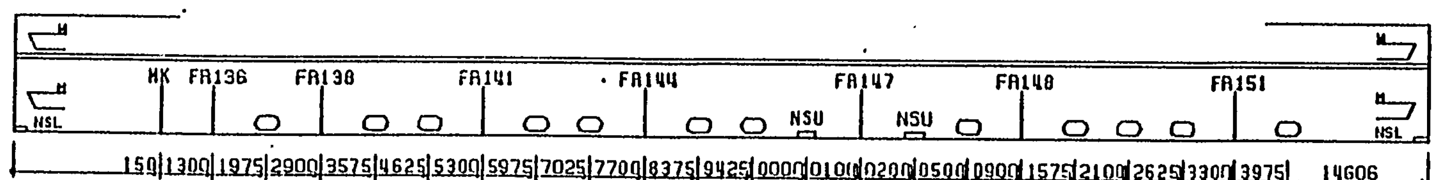

(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | -S-AL3 | 1 | | 1 | P-IN | 250 X 90 X12 / 16 | DA3L | AM | | 96.0 | | FW N+6 |



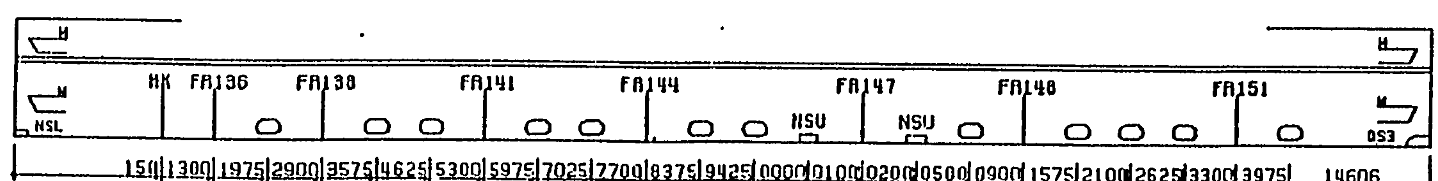

(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | -S-AL4 | 5 | | 5 | P-IN | 250 X 90 X12 / 16 | DA3L | AM | | 486.0 | | FW N+6 |




(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PAM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | -S-AL4A | 2 | | 2 | P-IN | 250 X 90 X12 / 16 | DA3L | AM | | 486.0 | | FW N+6 |




(FW)

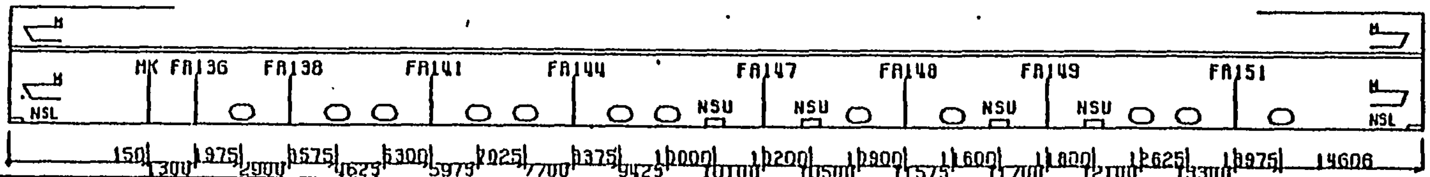
TOTAL WEIGHT 7668.0 TOTAL LENGTH 230465.9 BLOCK DS6

| SHIP NO | BLOCK | FAB. SHOP |
|---|---|---|
| 2715 | DS6 | |

# ANGLE

DATE 78. 5 .23 PAGE 2

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | -S-ALS | 2 | | 2 | P-IN | 250 X 90 X12 / 16 | DR3L | AM | | 486.0 | | FW N+6 |




(FW)

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | | | | | | |

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | | | |

| NO | PART CODE | | P | C | S | SHOWN | SCANTLING | HOLE | GRADE | S.PRM | WEIGHT | C.OF G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | | | | | | |

TOTAL WEIGHT 1944.0 TOTAL LENGTH 58424.0 BLOCK DS6

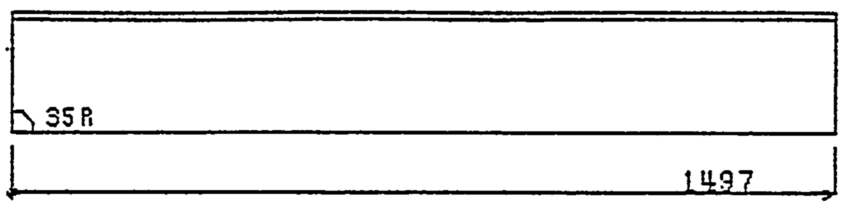
# ANGLE

SHIP NO 2715 BLOCK DS6 FAB.SHOP

DATE 78. 5 .23 PAGE 1

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|
| 1 | -43-A1=T | 1 | | 1 | P-FW | 200X90 X9 /14 | 34.0 | 748 |

NOTES




(UP)

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | |

NOTES

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | |

NOTES

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C.OF G |
|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | |

NOTES

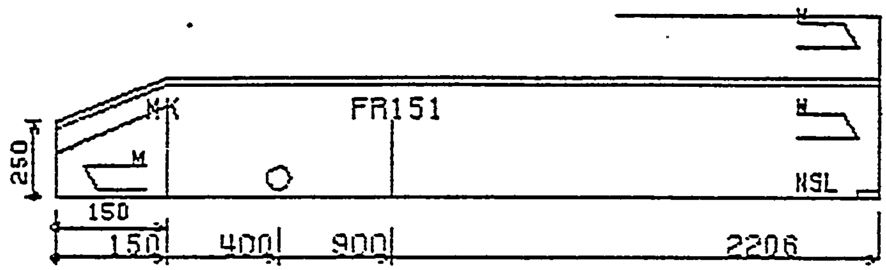
TOTAL WT. 68.0 TOTAL L. 2994.0 BLOCK DS6

SHIP NO 2715 | BLOCK DS6 | FAB.SHOP

# ANGLE

DATE 78. 5 .23 PAGE 1

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C. OF G |
|---|---|---|---|---|---|---|---|---|
| 1 | -AL6 | 12 | | 12 | S-IN | 300 X90 X 11 / 16 | 78.0 | |




NOTES

FW

N+G

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C. OF G |
|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | |

NOTES

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C. OF G |
|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | |

NOTES

| NO | PART CODE | P | C | S | SHOWN | SCANTLING | WEIGHT | C. OF G |
|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | |

NOTES

TOTAL WEIGHT 1872.0

TOTAL LEN[illegible] 3

船殼 HULL PARTS LIST 部品表

for Assembly

注1) 1サフ内個数 上段ワP玄 下段ワS玄
注2) 製造数 上段ワ所属玄 下段ワ脊舷玄

| CEQ No | 名称 | | 長 (M) | 巾 (MM) | 厚 (MM) | 材質 | 単品重量 (kg) | P | C | S | 改正 | 図面頁 | データ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | | | | | | | | |
| 02 | ** SKIN ** | | . | | . | | 30544. | | | | | | |
| 03 | | | | | | | | | | | | | |
| 04 | C | | . | | 32. | | 10259. | 1 | | 1 | | | |
| 05 | | | | | | | | | | | | | |
| 06 | D | | . | | 32. | | 10259. | 1 | | 1 | | | |
| 07 | | | | | | | | | | | | | |
| 08 | E | | . | | 32. | | 10259. | 1 | | 1 | | | |
| 09 | | | | | | | | | | | | | |
| 10 | F | | . | | 32. | | 9767. | 1 | | 1 | | | |
| 11 | | | | | | | | | | | | | |
| 12 | | | . | | . | | . | | | | | | |
| 13 | | | | | | | | | | | | | |
| 14 | | | . | | . | | . | | | | | | |
| 15 | | | | | | | | | | | | | |
| 16 | | | . | | . | | . | | | | | | |
| 17 | | | | | | | | | | | | | |
| 18 | | | . | | . | | . | | | | | | |
| 19 | | | | | | | | | | | | | |
| 20 | ** BARA ** | | . | | . | | 5751. | | | | | | . |
| 21 | | | | | 10/15 | | | | | | | | |
| 22 | AL1 | | 124 | 250* | 90* | | 360. | 8 | | 8 | | | T |
| 23 | | | | | 10/15 | | | | | | | | |
| 24 | AL2 | | 78 | 250* | 90* | | 226. | 1 | | 1 | | | T |
| 25 | | | | | 10/15 | | | | | | | | |
| 26 | AL3 | | 4606 | 250* | 90* | | 133. | 1 | | 1 | | | T |
| 27 | | | | | 10/15 | | | | | | | | |
| 28 | AL4 | | 101 | 250* | 90* | | 293. | 1 | | 1 | | | T |
| 29 | | | | | 10/15 | | | | | | | | |
| 30 | AL5 | | 133 | 250* | 90* | | 386. | 1 | | 1 | | | T |
| 31 | | | | | 11/16 | | | | | | | | |
| 32 | AL6 | | 22 | 300* | 90* | | 78. | 12 | | 12 | | | T |
| 33 | | | | | 10/15 | | | | | | | | |
| 34 | AL7 | | 78 | 250* | 90* | | 226. | 3 | | 3 | | | T |
| 35 | | | | | | | | | | | | | |
| 36 | ZQE2L | A | . | | . | | 8. | | | 16 | | | |
| 37 | | | | | | | | | | | | | |
| 38 | ZQE2Q | A | . | | . | | 11. | | | 1 | | | |
| 39 | | | | | | | | | | | | | |
| 40 | ZQE3L | A | . | | . | | 8. | 16 | | | | | |
| 41 | | | | | | | | | | | | | |
| 42 | ZQE3Q | A | . | | . | | 11. | 1 | | | | | |
| 43 | | | | | | | | | | | | | |
| 44 | ZCB4G | A | . | | . | | 2. | 15 | | 15 | | | |
| 45 | | | | | | | | | | | | | |
| 46 | ZCB4L | A | . | | . | | 3. | 5 | | 5 | | | |
| 47 | | | | | | | | | | | | | |
| 48 | F1 | | . | 180* | 11. | | 10. | 1 | | 1 | | | |

(4730)

年 月 日 調整 1978 05 23 ASS LIST -01- 番船 2715 ブロック名 DS6 中組

船殻
Hull parts list
部品表

for Assembly

注1）1サブ内個数
上段ワP玄
下段ワS玄
注2）製造数
上段ワ所属玄
下段ワ存在玄

| No. | 名称 | 長 (M) | 巾 (MM) | 厚 (MM) | 材質 | 単品重量 (kg) | 1サブ内個数 | 製造数 P | C | S | 改正 | 図面頁 | データ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | | | | | | | | | |
| 02 | F2 | . | 200* | 12. | | 18. | | 1 | | 1 | | | | |
| 03 | | | | | | | | | | | | | | |
| 04 | B1 | . | | 10. | | 7. | | 1 | | 1 | | | C | |
| 05 | | | | | | | | | | | | | | |
| 06 | | . | | . | | . | | | | | | | | |
| 07 | | | | | | | | | | | | | | |
| 08 | | . | | . | | . | | | | | | | | |
| 09 | | | | | | | | | | | | | | |
| 10 | | . | | . | | . | | | | | | | | |
| 11 | | | | | | | | | | | | | | |
| 12 | | . | | . | | . | | | | | | | | |
| 13 | | | | | | | | | | | | | | |
| 14 | ** SUB ** | . | | . | | 31983. | | | | | | | | |
| 15 | | | | | | | | | | | | | | |
| 16 | 1 | . | | . | | 981. | | 1 | | 1 | | | | |
| 17 | | | | | | | | | | | | | | |
| 18 | 2 | . | | . | | 168. | | 1 | | 1 | | | | |
| 19 | | | | | | | | | | | | | | |
| 20 | 3 | . | | . | | 82. | | 1 | | 1 | | | | |
| 21 | | | | | | | | | | | | | | |
| 22 | 31 | . | | . | | 1266. | | 1 | | 1 | | | | |
| 23 | | | | | | | | | | | | | | |
| 24 | 32 | . | | . | | 528. | | 1 | | 1 | | | | |
| 25 | | | | | | | | | | | | | | |
| 26 | 33 | . | | . | | 527. | | 1 | | 1 | | | | |
| 27 | | | | | | | | | | | | | | |
| 28 | 34 | . | | . | | 192. | | 1 | | 1 | | | | |
| 29 | | | | | | | | | | | | | | |
| 30 | 41 | . | | . | | 3613. | | 1 | | 1 | | | | |
| 31 | | | | | | | | | | | | | | |
| 32 | 42 | . | | . | | 3449. | | 1 | | 1 | | | | |
| 33 | | | | | | | | | | | | | | |
| 34 | 43 | . | | . | | 3401. | | 1 | | 1 | | | | |
| 35 | | | | | | | | | | | | | | |
| 36 | 44 | . | | . | | 3782. | | 1 | | 1 | | | | |
| 37 | | | | | | | | | | | | | | |
| 38 | DS-1 | . | | . | | 501. | | 2 | | 2 | | | | |
| 39 | | | | | | | | | | | | | | |
| 40 | DS-1A | . | | . | | 502. | | 1 | | 1 | | | | |
| 41 | | | | | | | | | | | | | | |
| 42 | DS-1B | . | | . | | 502. | | 1 | | 1 | | | | |
| 43 | | | | | | | | | | | | | | |
| 44 | DS-2 | . | | . | | 503. | | 3 | | 3 | | | | |
| 45 | | | | | | | | | | | | | | |
| 46 | DS-2A | . | | . | | 504. | | 1 | | 1 | | | | |
| 47 | | | | | | | | | | | | | | |
| 48 | DS-3 | . | | . | | 503. | | 4 | | 4 | | | | |

(4730)

年 月 日 調整 1978 05 23 ASS LIST -02-

番船 2715 ブロック名 FS6 中組

P 02-

# 船殻 Hull PARTS LIST 部品表

for Assembly

注1) 1サブ内個数
上段ワPエ
下段ワSエ
注2) 製造数
上段ワ所要エ
下段ワ存在エ

| No | 名称 | 長 (M) | 巾 (MM) | 厚 (MM) | 材質 | 単品重量 (kg) | P | C | S | 改正 | 図面頁 | データ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | | | | | | | |
| 02 | DS-4 | . | | . | | 792. | 2 | | 2 | | | |
| 03 | | | | | | | | | | | | |
| 04 | DS-4A | . | | . | | 895. | 1 | | 1 | | | |
| 05 | | | | | | | | | | | | |
| 06 | DS-4B | . | | . | | 701. | 1 | | 1 | | | |
| 07 | | | | | | | | | | | | |
| 08 | DS-6 | . | | . | | 655. | 1 | | | | | |
| 09 | | | | | | | | | | | | |
| 10 | DS-6B | . | | . | | 655. | | | 1 | | | |
| 11 | | | | | | | | | | | | |
| 12 | DS-7 | . | | . | | 655. | 1 | | 1 | | | |
| 13 | | | | | | | | | | | | |
| 14 | DS-8 | . | | . | | 655. | 1 | | 1 | | | |
| 15 | | | | | | | | | | | | |
| 16 | DS-9 | . | | . | | 179. | 1 | | 1 | | | |
| 17 | | | | | | | | | | | | |
| 18 | DS-10 | . | | . | | 168. | 1 | | 1 | | | |
| 19 | | | | | | | | | | | | |
| 20 | DS-11 | . | | . | | 167. | 1 | | 1 | | | |
| 21 | | | | | | | | | | | | |
| 22 | DS-13 | . | | . | | 496. | 1 | | 1 | | | |
| 23 | | | | | | | | | | | | |
| 24 | DS-14 | . | | . | | 496. | 1 | | 1 | | | |
| 25 | | | | | | | | | | | | |
| 26 | DS-15 | . | | . | | 496. | 1 | | 1 | | | |
| 27 | | | | | | | | | | | | |
| 28 | DS-16 | . | | . | | 726. | 1 | | 1 | | | |
| 29 | | | | | | | | | | | | |
| 30 | | . | | . | | . | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | | . | | . | | . | | | | | | |
| 33 | | | | | | | | | | | | |
| 34 | | . | | . | | . | | | | | | |
| 35 | | | | | | | | | | | | |
| 36 | | . | | . | | . | | | | | | |
| 37 | | | | | | | | | | | | |
| 38 | ** M-ASS ** | . | | . | | 29099. | \ | | | | | |
| 39 | | | | | | | | | | | | |
| 40 | S | . | | . | | 29099. | 1 | | 1 | | | |
| 41 | | | | | | | | | | | | |
| 42 | | . | | . | | . | | | | | | |
| 43 | | | | | | | | | | | | |
| 44 | | . | | . | | . | | | | | | |
| 45 | | | | | | | | | | | | |
| 46 | | . | | . | | . | | | | | | |
| 47 | | | | | | | | | | | | |
| 48 | | . | | . | | . | | | | | | |

(4730)

年 月 日 調整 1978 05 23 ASS LIST 03

番船 2715 ブロック名 DS6 中組

# 船殻 HULL PARTS LIST 部品表

for Sub assembly

注1) 1サブ内個数
上段ワP玄
下段ワS玄
注2) 製造数
上段ワ所属玄
下段ワ存在玄

| CEQ No. | 名称 | 長 (M) | 巾 (MM) | 厚 (MM) | 材質 | (kg) 単品重量 | 内数 | 製造数 P | 製造数 C | 製造数 S | 改正 | 図面頁 | データ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | | | | | | | | | |
| 02 | 1 | . | | . | | 981. | | 1 | | 1 | | | | |
| 03 | | | | | | | | | | | | | | |
| 04 | W1 | . | | 15. | | 849. | | 1 | | 1 | | | C | |
| 05 | | | | | | | | | | | | | | |
| 06 | B1 | . | | 11. | | 4. | | 1 | | 1 | | | C | |
| 07 | | | | | | | | | | | | | | |
| 08 | B2 | . | | 11. | | 4. | | 1 | | 1 | | | C | |
| 09 | | | | | | | | | | | | | | |
| 10 | DS-F5 | 1609 | 200* | 13. | | 32. | | 1 | | 1 | | | I | |
| 11 | | | | | | | | | | | | | | |
| 12 | DS-F6 | 1383 | 200* | 13. | | 28. | | 1 | | 1 | | | I | |
| 13 | | | | | | | | | | | | | | |
| 14 | DS-F7 | 1609 | 200* | 13. | | 32. | | 1 | | 1 | | | I | |
| 15 | | | | | | | | | | | | | | |
| 16 | DS-F8 | 1597 | 200* | 13. | | 32. | | 1 | | 1 | | | I | |
| 17 | | | | | | | | | | | | | | |
| 18 | | . | | . | | . | | | | | | | | |
| 19 | | | | | | | | | | | | | | |
| 20 | | . | | . | | . | | | | | | | | |
| 21 | | | | | | | | | | | | | | |
| 22 | | . | | . | | . | | | | | | | | |
| 23 | | | | | | | | | | | | | | |
| 24 | | . | | . | | . | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 26 | 2 | . | | . | | 168. | | 1 | | 1 | | | | |
| 27 | | | | | | | | | | | | | | |
| 28 | W1 | . | | 13. | | 133. | | 1 | | 1 | | | C | |
| 29 | | | | | | | | | | | | | | |
| 30 | T1 | 2315 | 150* | 13. | | 35. | | 1 | | 1 | | | I | |
| 31 | | | | | | | | | | | | | | |
| 32 | | . | | . | | . | | | | | | | | |
| 33 | | | | | | | | | | | | | | |
| 34 | | . | | . | | . | | | | | | | | |
| 35 | | | | | | | | | | | | | | |
| 36 | | . | | . | | . | | | | | | | | |
| 37 | | | | | | | | | | | | | | |
| 38 | | . | | . | | . | | | | | | | | |
| 39 | | | | | | | | | | | | | | |
| 40 | 3 | . | | . | | 82. | | 1 | | 1 | | | | |
| 41 | | | | | | | | | | | | | | |
| 42 | W1 | . | | 13. | | 65. | | 1 | | 1 | | | C | |
| 43 | | | | | | | | | | | | | | |
| 44 | T1 | 1114 | 150* | 13. | | 17. | | 1 | | 1 | | | I | |
| 45 | | | | | | | | | | | | | | |
| 46 | | . | | . | | . | | | | | | | | |
| 47 | | | | | | | | | | | | | | |
| 48 | | . | | . | | . | | | | | | | | |

(4730)

| 年 月 日 調整 | | | | | | 番船 | ブロック名 | 中組 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 05 | 23 | SUB | LIST | -01- | 2715 | DS6 | | | P 04- |

APPENDIX C

SUMMARY OF IHI SHELL

SUMMARY OF IHI

# SHELL

ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES IHI

**Ishikawajima-Harima**

Heavy Industries Co., Ltd.

TOKYO JAPAN

C o n t e n t s

# 1. General aspect of SHELL system

## 1-1 Purpose of the development of SHELL system

This system constitutes an integrated, computerised data processing system that provides various highly accurated and utilizable informations pertaining to all the process in production of curved shell blocks from the shell expansion in design section or mould loft to the block assembly in shop.

In the conventional system, shell expansion, jig calculation of the curved shell blocks, etc., are also carried out by numerical calculation by the medium of an offsets data bank ( as original data file ) and they were improving and brushing up passing through a lot of trials and errors based on the fed back data from the production field. However, the system was merely constituted single-purpose programs being concerned to the jobs in mould loft.

Purpose of the new development of SHELL system is to obtain the most optimum informations to meet the needs in the respestive process in production. For the purpose of it, a certain number of standardized production technologies and application know-hows are stored in the system and the planners are able to put their option into the system by means of inputs according to the situation of the shop. The standardization of production technologies and analysis of application know-hows in SHELL system have been established by mobilizing of the engineering power in IHI's five shipyards.
The said standardization and analysis are the another significant fruit of the new development of SHELL system.

## 1-2 Charactaristics of SHELL system

### 1-2-1 Designing policy of SHELL system

The following considerations were put into

1)Lines on the optional cut plane at designer's direction to be used for the calculations, in the system.

2) Lines data to be-stored in the bank by a certain concurrence of points on the respective line which is approximated by straight lines.

3) A common offsets data bank to be installed in the system, to which required data to be shifted from the respective data base in each subsystem passing through a certain conversion program.

4) The templetes to check the curveture of shell plates are to be designed standing at right angle against the mean level of the curved plate when it is on the bending slab.

5) Figure of a expanded shell plate to be calculated as a part of the ship's surface including surounded

6) Geodestic line method and rolling method to de adopted in the system as the developing logics for shell expansion.

7) A corrective routine to be installed in the system to modify the shape of expanded shell plate after running

### 1-2-2 Charactaristics of SHELL system

1) SEELL system is a composite system for the geometri calculation and data processing system relevant to the production of curved shell blocks in ship

follows:

2) The calculating logics are of simple and higher level of accuracies are uniformally displayed in the outputs by the system, since the lines in the offsets bank are dram by the concurrences of points approximated by a certain supplementary straight lines.

b) The higher accurated shell expansions are achieved *easily by this system,* since the optional cut plane method is fully adopted for the expansions.

( Refer to Fig.1 )

c) Unified accuracy on the peripheral parts of an. expanded shell plate is ensured, since the desired plate is cut out of a larger expanded plan includ- *ing* the surounded area of the plate.

d) The *geometrical* formal **check** of the curved plate by the templetes becomes easier to ensure the accuracy, since the templetes are set up at the right angle against the mean level of the curved plate.

( Refer to Fig. 2 & 3 )

4) A remarkable improvement on the workability and accuracy in the assembly stage can be expected, since the various working practices in the Shop are taking into considered from the first step of the system running, as follows:

2) SINGLE PANEL ASSMBLY system is available.

**Refer to Fig. 4 & 5 )**

b) Since the intersections of datum planes in the *supporting jig lines* and shell plates are marked on each shell plate and, in addition, the datum planes ***are*** orthogona1 to the platform surface, the accuracy of angles between contiguous seam and butt can be maintained easily.

( Refer Fig. 6 & 7 )

c) **Instructions can** be given in connection with the *position* for plate setting, position of stopper and the height of additional supporting jigs, if required.

d) Data for accuracy *control relating to- the dimension* of black, diagonal dimension, date of curveture on seam and butt, etc., are output by the system.

e) The availability of automatic welding on the block can be checked by the system, if required.

5) Easy to maintenance of the system.

The partial revision of the system, *rather easy,* since the system of workinig with modules is adopted and the logical constitution of the system is simpler.

6) Easy to replacement of data in the data files.'

Since the system has 2 main offsets data bank and peripheral data files separatory, replacement of data can be made indipendently when it becomes necessary.-

7) Easy to manual correction of the outputs.

Partia1 manual c orrection for the output of shell expansions available in accordance with the change- ment of working process and/or *expansion* method.

8) Easy recording of fed back data.

Quantative data such as **distortion caused** by locked- in stress due to press or heating, in particular, can be fed into the system from-time to time and recorded them-as reference data *for system.* improvement in-future.

Fig. 1 ONE EXAMPLE OF OPTIONAL CUT PLANE PROCESS

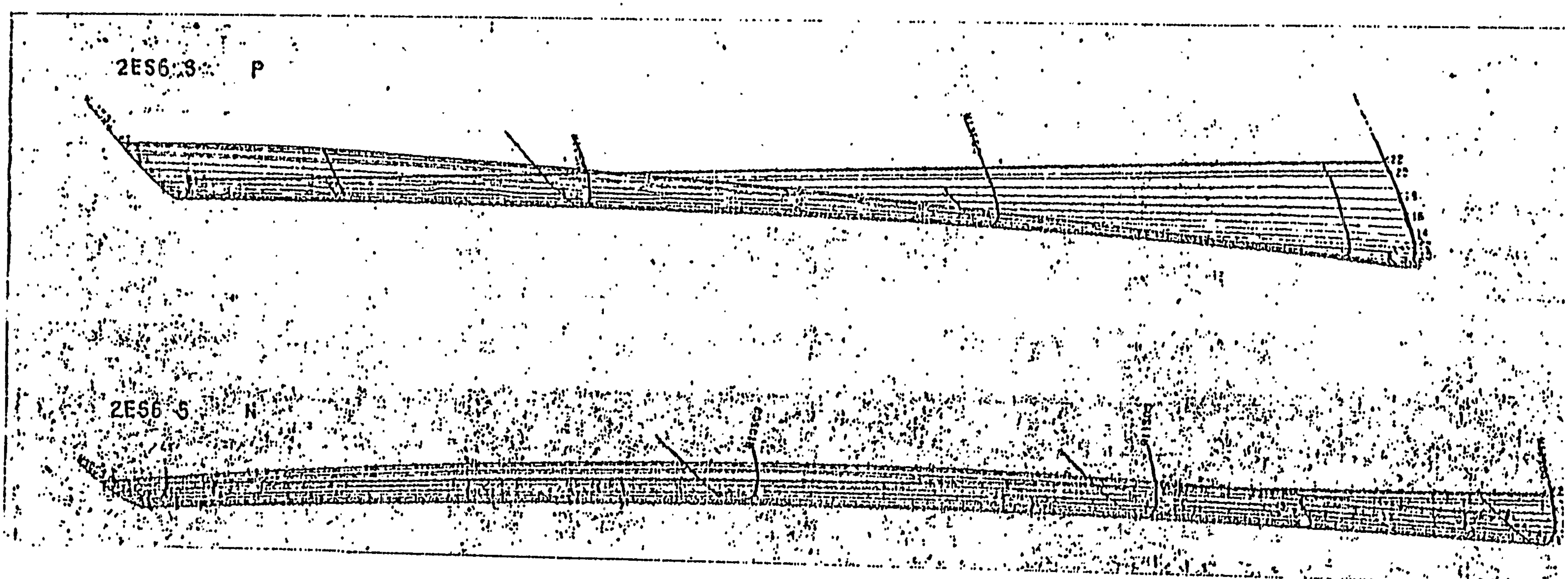
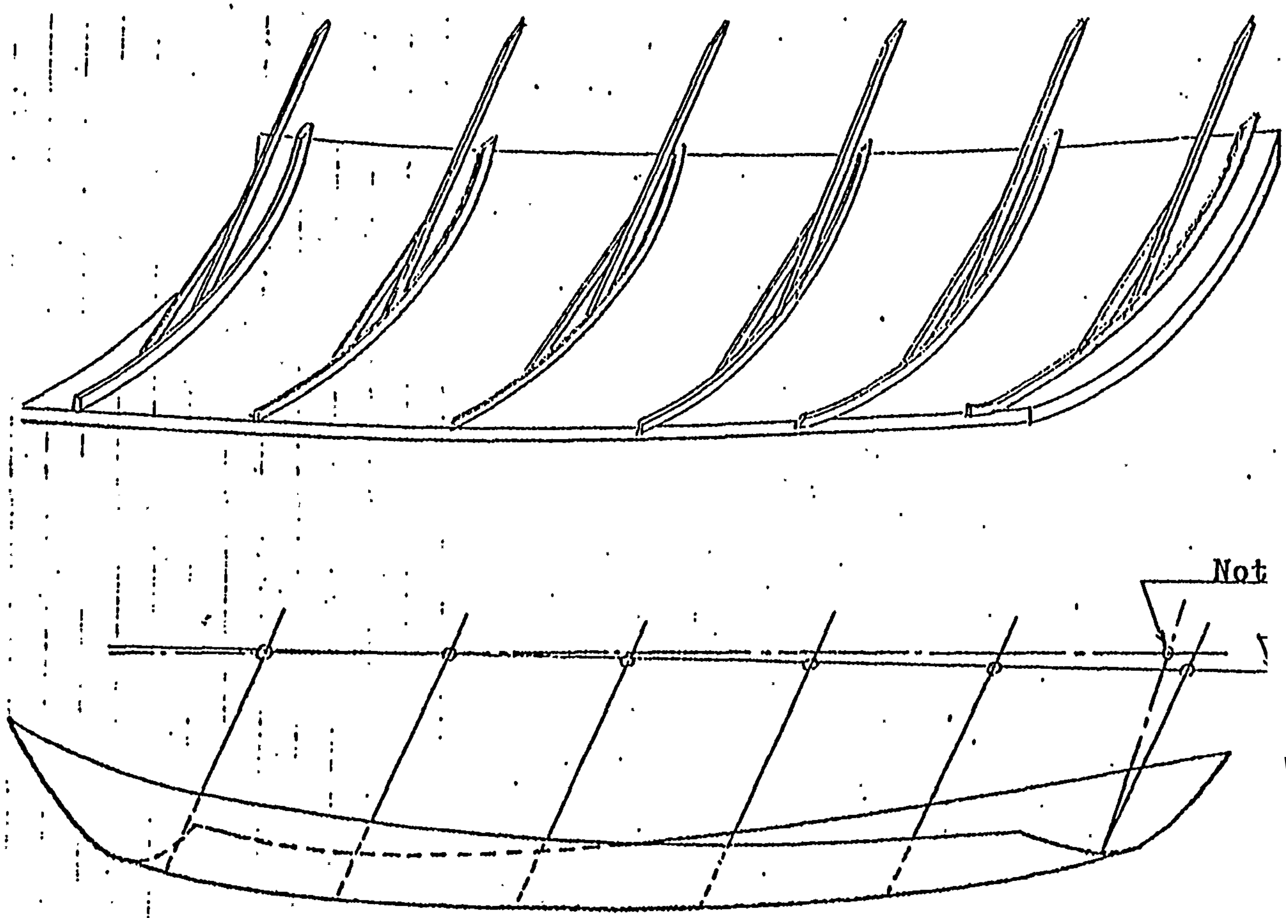
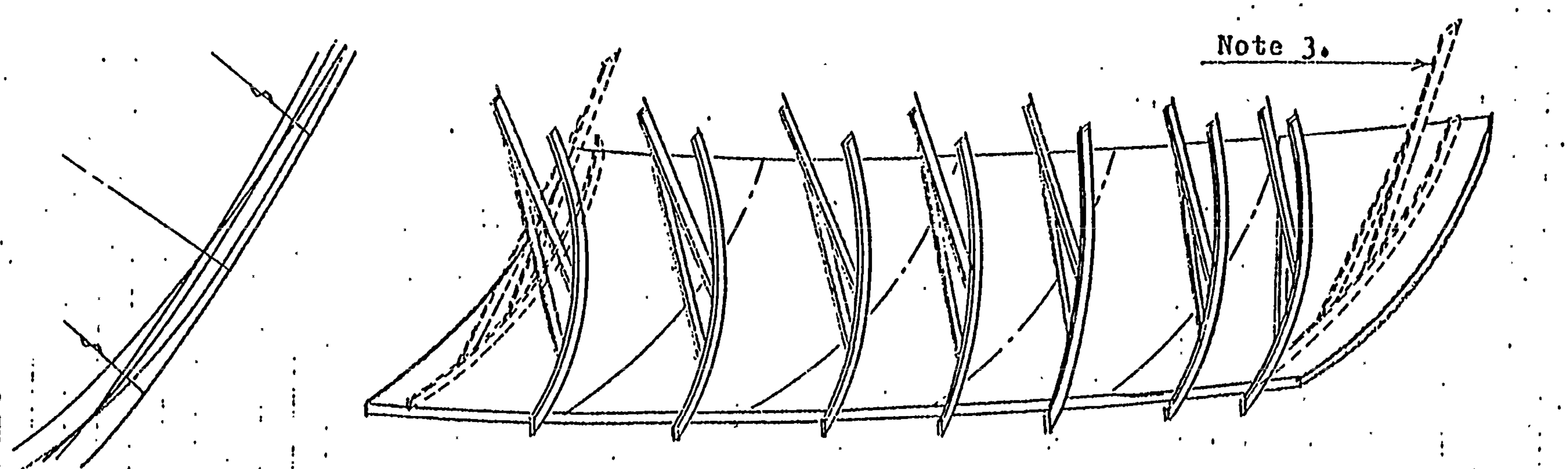


Fig. 2 ARRANGEMENT OF TEMPLETES BY THE CONVENTIONAL SYSTEM



Note 1.
When the setting angle of the templetes against the mean level of the curved plate are far from right angle, the errors of setting angle become a source of bigger error of sight line to the check. In the other words, the accuracy of longitudinal curveture shall be debased by the errors of the setting angles.

## Fig. 3 ARRANGEMENT OF TEMPLETES BY " SHELL " SYSTEM




Note 3. Templete for the final check

Note 1.
The errors in the setting angle of templetes have few effects for the accuracy of the longitudinal curvetures of the plate.

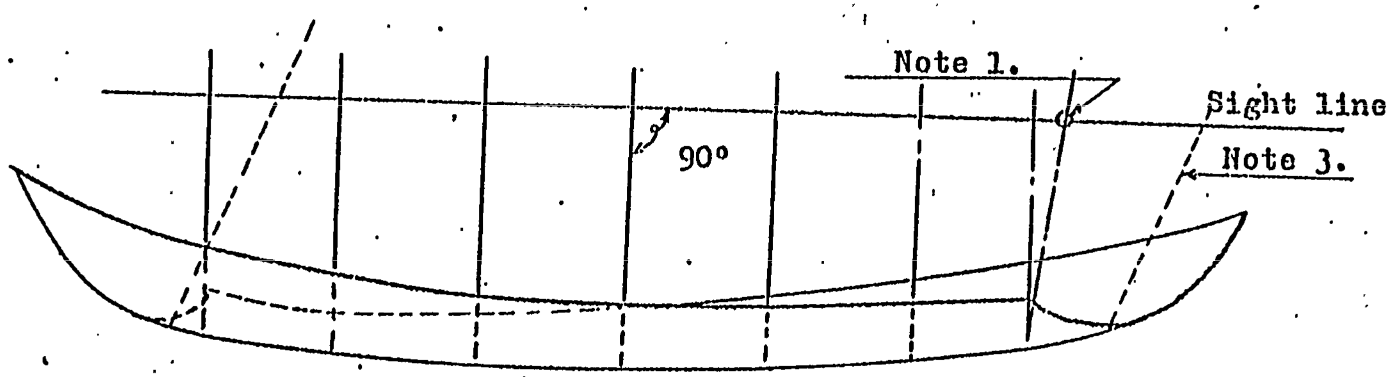
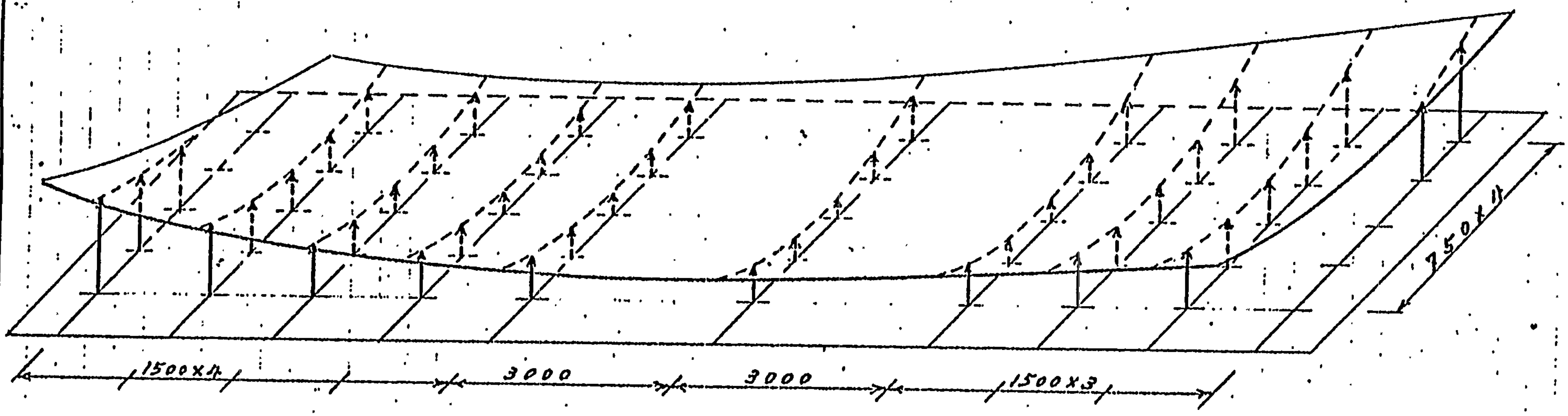


Fig. 4 SUPPORTING JIGS FOR SINGLE PANEL

Longitudinals are subassembled on each curved plate before panel assembly.

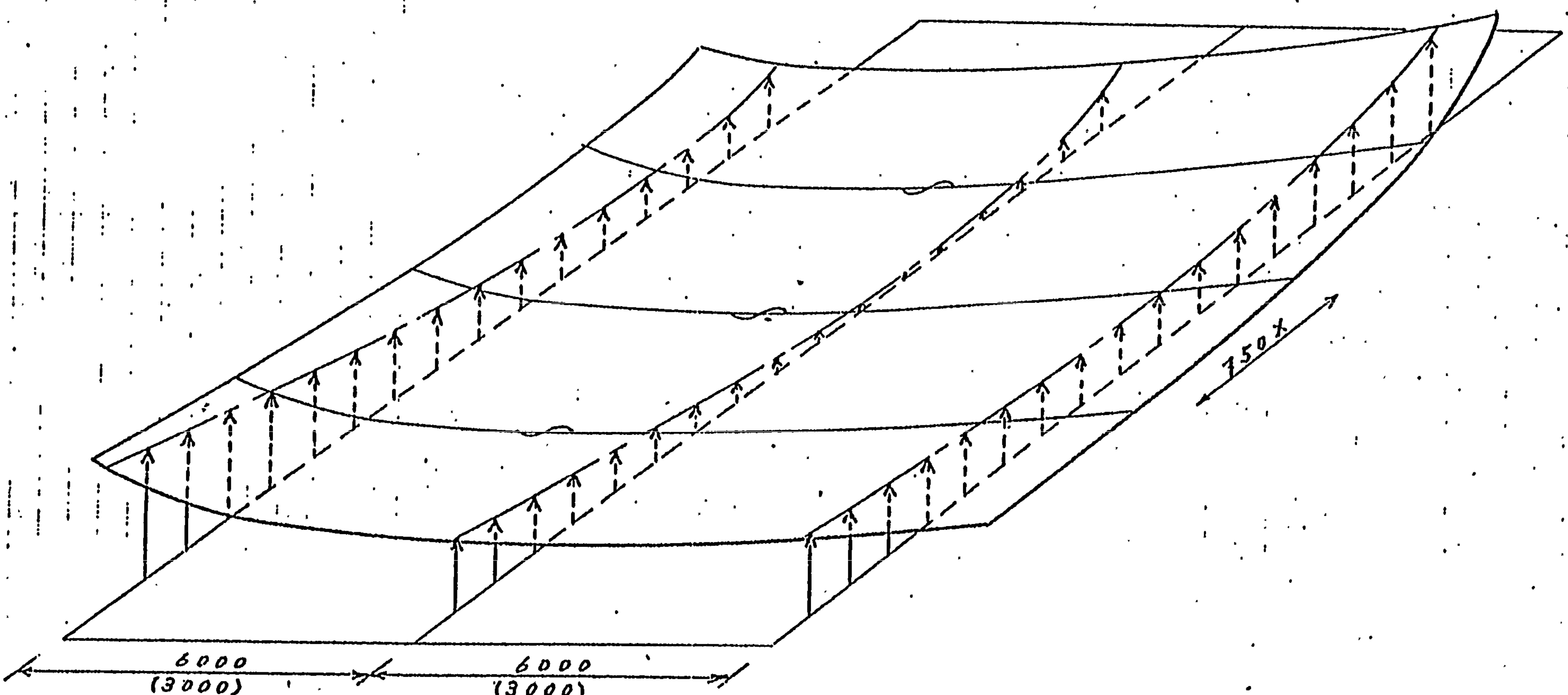



Height of jigs are adjusted automatically according to the input by paper tape.

Ishikawajima-Harima Heavy Industries Co., Ltd.

Fig. 5 BLOCK SUPPORTING JIGS IN SINGLE PANEL ASSEMBLY SYSTEM

Subassembled panels are assembled on the jigs.

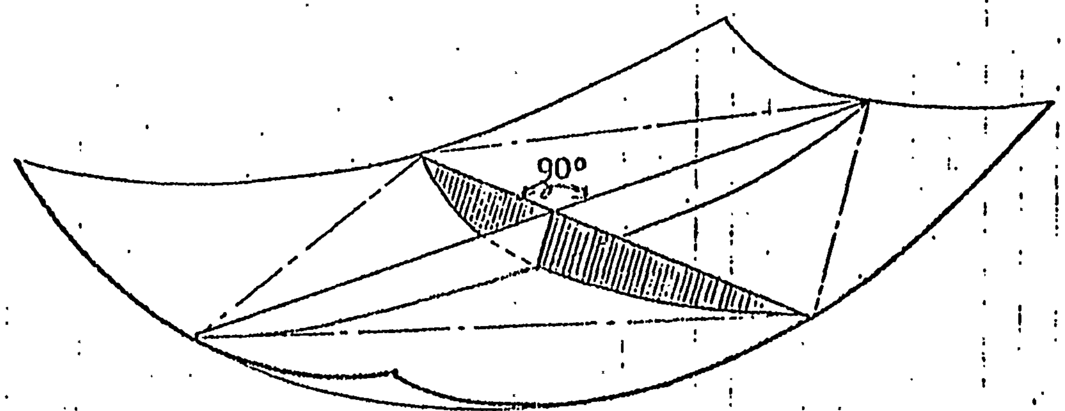



Ishikawajima-Harima Heavy Industries Co., Ltd.

Fig. 6 DATUM PLANE FOR BLOCK ASSEMDLY (1/2)

1. Conventional method

Datum planes in which the datum lines for the block marking are involved, are not orthogonal to the platform, since the datum planes are determined from the cross-section body plan.




2. SHELL method

Datum planes are orhtogonal to the platform plane.
Transit and laser are the available tools to get the higher accuracy of the block assembly.

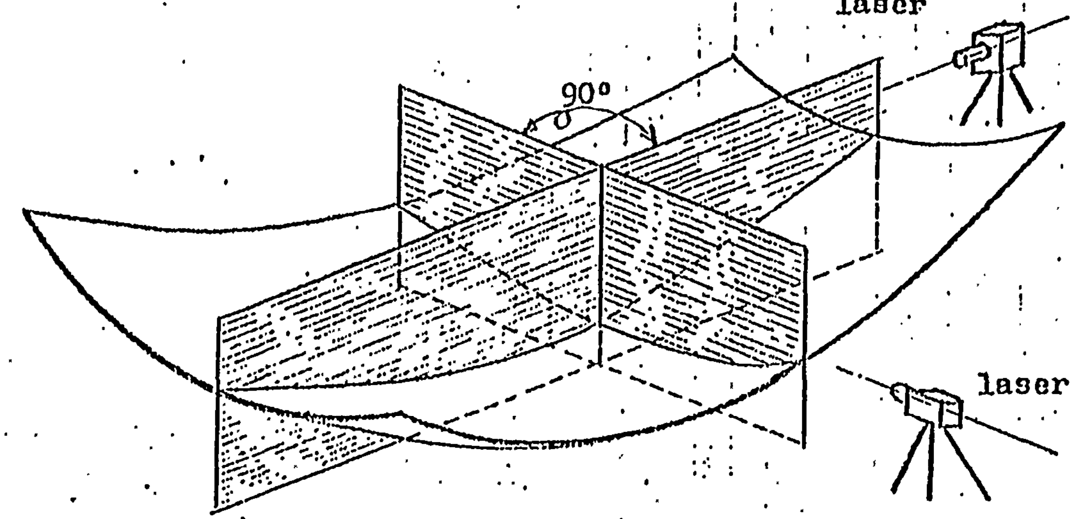
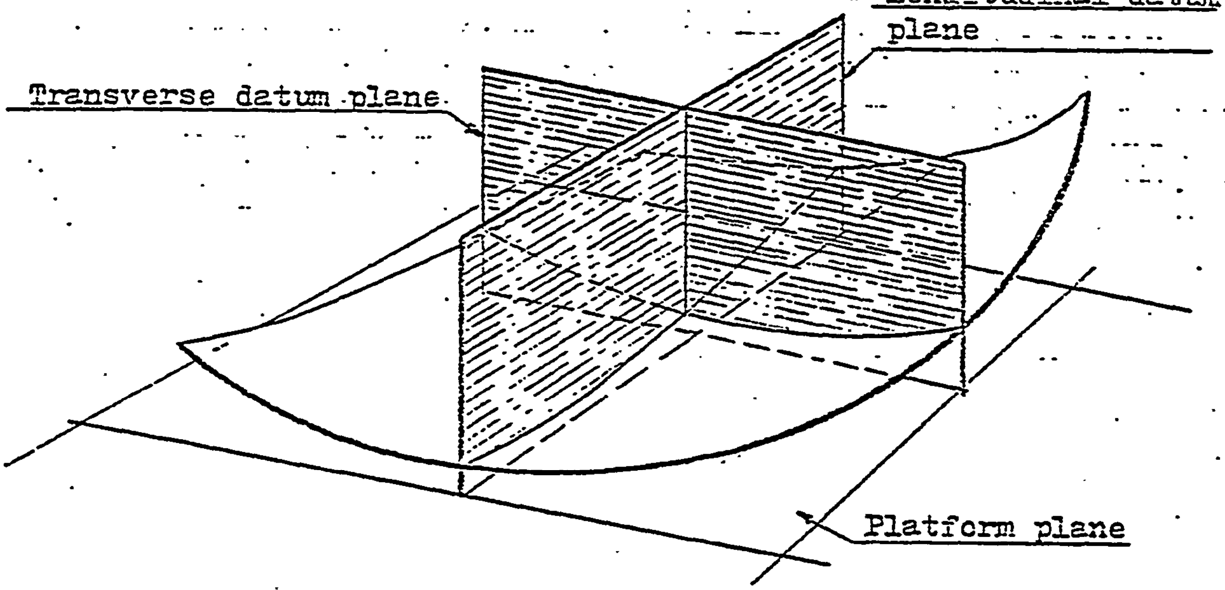


Fig. 7 DATUM PLANES OF SUPPORTING JIGS




1. The datum planes of the transverse and longitudinal supporting jig lines are mutually orthogonal and also are orthogonal to the platform plane.
2. The inter section of the datum planes and shell plates are the datum lines for the block marking.
3. Those datum lines of block marking are marked on each shell plate in the fabrication shop.
4. Since both datum planes are orthogonal to the platform plane, the check of datum lines will be easy.
   In addition, these planes become the vital medium to maintain the accuracy of block marking. Accordingly, the accuracy as well as the workability are improved in the field.

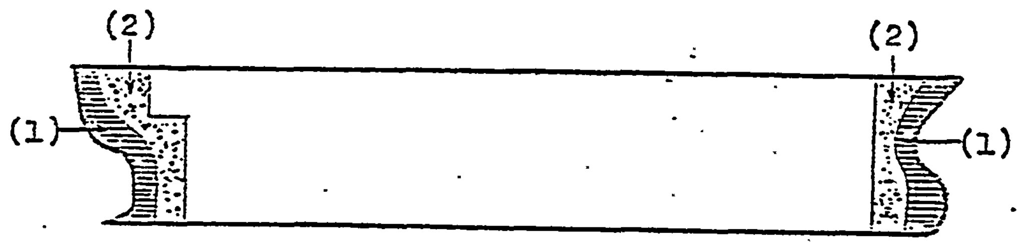
## 1-3 Scope of application of SHELL system

According to the current version, SHELL system is applicable to all shell plates other than stern plates and stem plates. Preparation are being advanced, however, to include even stern and stem plates in the scope of application of SHELL system in the near future.

1) Functional limitations

a) SHELL system can not be applied to the processing of stern and stem plates. ——— (1)

b) As for the plates adjacent to stern and stem plates, it is required to supplement the offsets data to process. ( PAN valet system ) ——— (2)




2) Operational limitations

a) When the offsets data bank is not available to the processing, a certain supplemental offsets data will be required by the manual input.

b) When the system is applied for a part of the ships, such as repair ships, etc., PAN valet system will be available to supplement the incomplete offsets data.

c) The operational limitations are also depending on the function of the gas cutting machines to be used for.

## 1-4 Operation of SHELL system

### l-4-1 Establishment of the operation system

SHELL system incorporates a wide scope of the application know-how in production and is designed for working with all kinds of related facility and production methods. For this very reason, its most optimum operation system be displayed only by the establishment of a suitable system for inducing it into the ship yards taking into consideration of computor or numerical control system and also working process in production. Namely, sufficient preliminary deliberation will be necessary to coordinate functional aptitude with the fabrication and the assembly stage, *as* follows:

* Preparation of base data ---------- Functional design
* Formal geometrial development -------- Applied design
* Post processor --Outpost of production data

To elaborate, 2 slient characteristics of SHELL system lies in the fact that system demands preliminary institution of a comprehensive production process engineering prior to its application.

### 1-4-2 Type of the application system

The the of the application systems may roughly classified into the followings:

a) Hand marking oriented type
b) Electro-photo marking oriented type
c) NC cutting oriented type
2) Hybrid electro-photo marking and NC cutting oriented

e) SINGLE PANEL ASSEMBLY system-oriented type

SHELL system provides highly accurated output data coducing to excellent workmanship for the all type

of application systems listed in the above listed.

### 1-4-3 Standardizaticn of production technologies and ifs application know-hows

SHELL system is an advanced and fruitful system constructed on the basis of the systematic standardized production technologies and higher leveled application know-hows in the each stages of production, such as cutting, bending, assembling, welding, etc., showing in the following Figs..

Fig. 8 RELATIONSHIP BETWEEN SHELL AND PRODUCTION PROCESSES

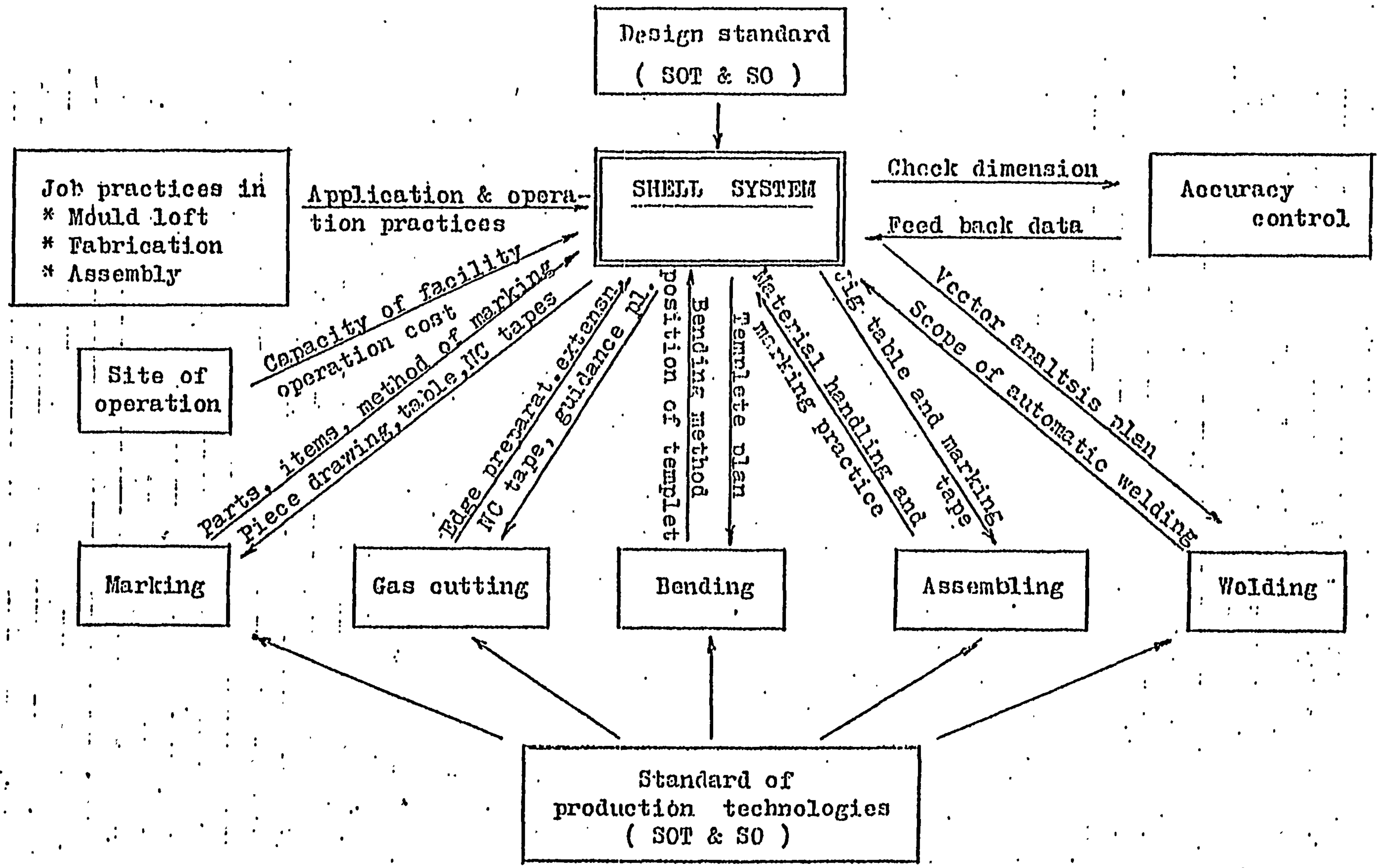
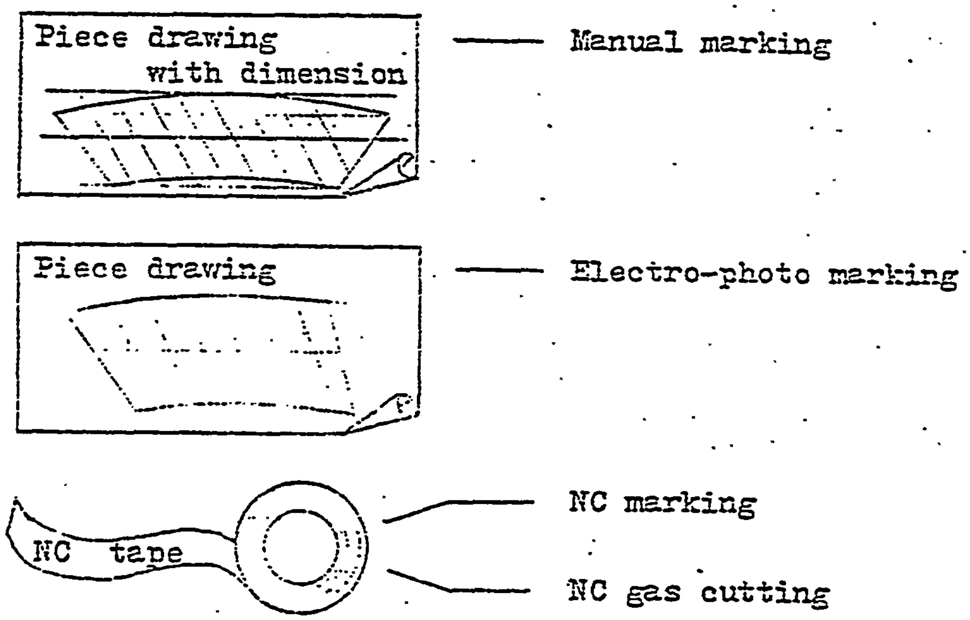
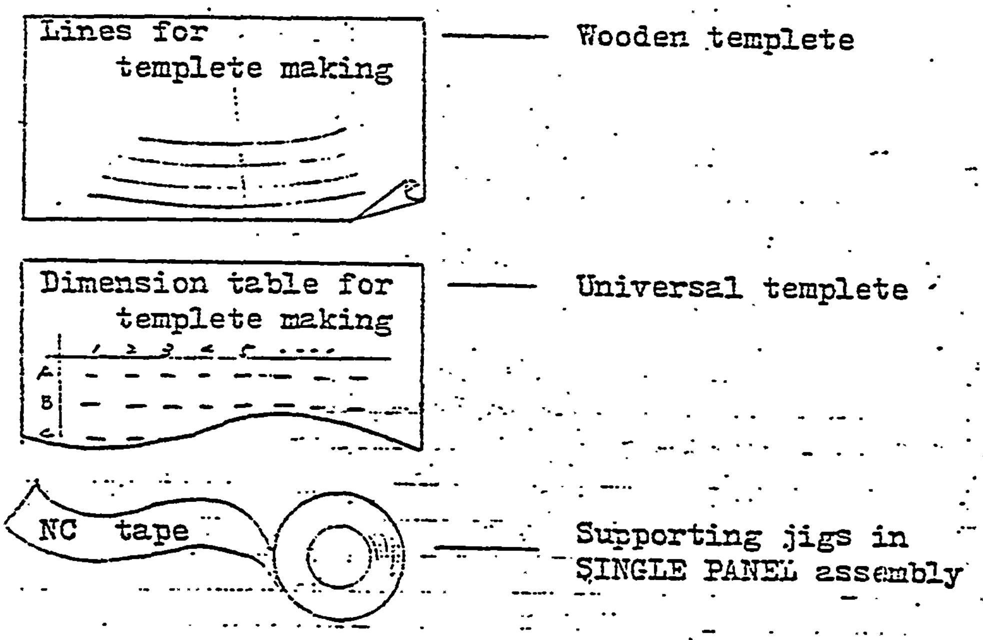


Fig. 9 OUTPUT CORRESPONDING TO WORKING PROCESS

A. Marking and gas cutting in fabrication stage.

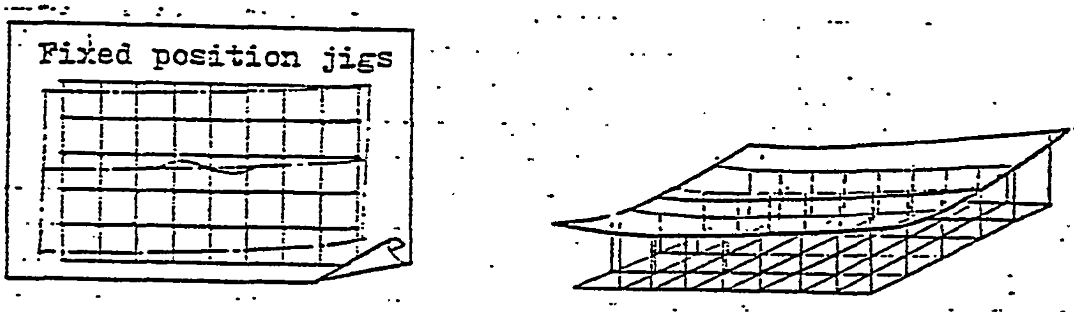


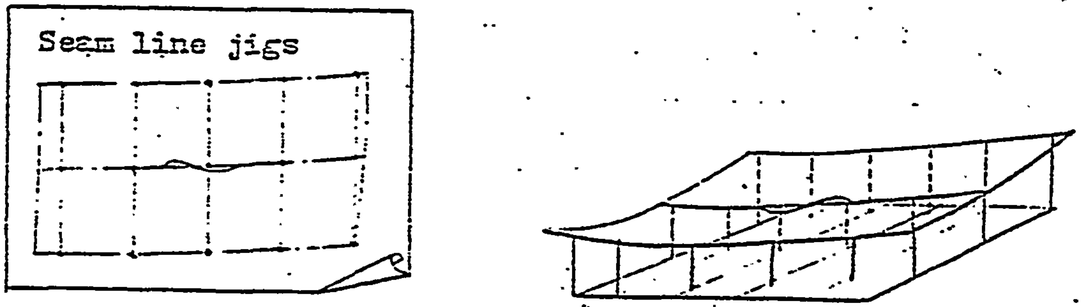

B. Plale bending

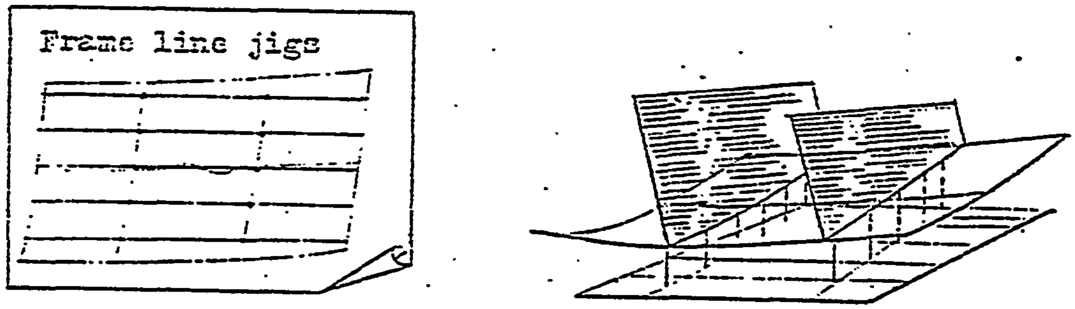


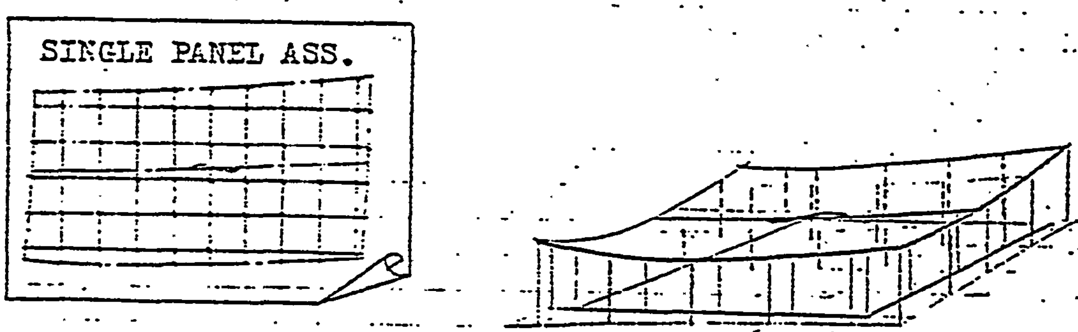
C. Supporting jigs in assembly stage.

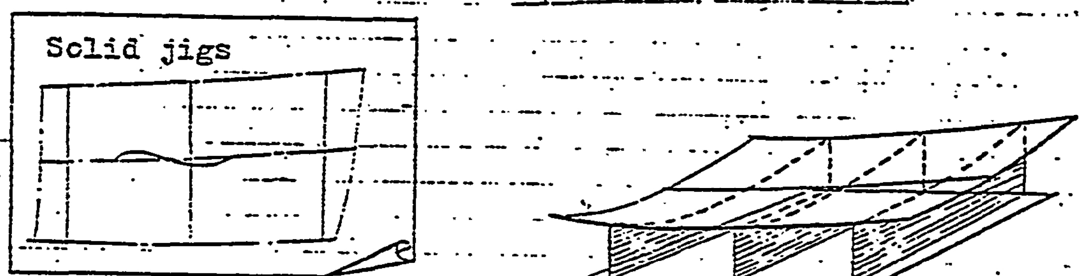
( Dimension plan - Jig heights )



## 2 System composition and Out line input/output of the system

### 2-1. Main computer and its terminal ecuipment

1) Main computer

a) IBM s/370 - 135/158 are available.
b) vs 1,2 to be used for the CS.
c) FORTRAN-G is available for the programming.
a) 3330-1 (N=1) to be used for the disk handling.

2) Terminal equipments

The terminal equipments for the outputs primarily consists of the drafting devices, for which the users are free to select the desired terminal equipments, which may consist of any of the followings:

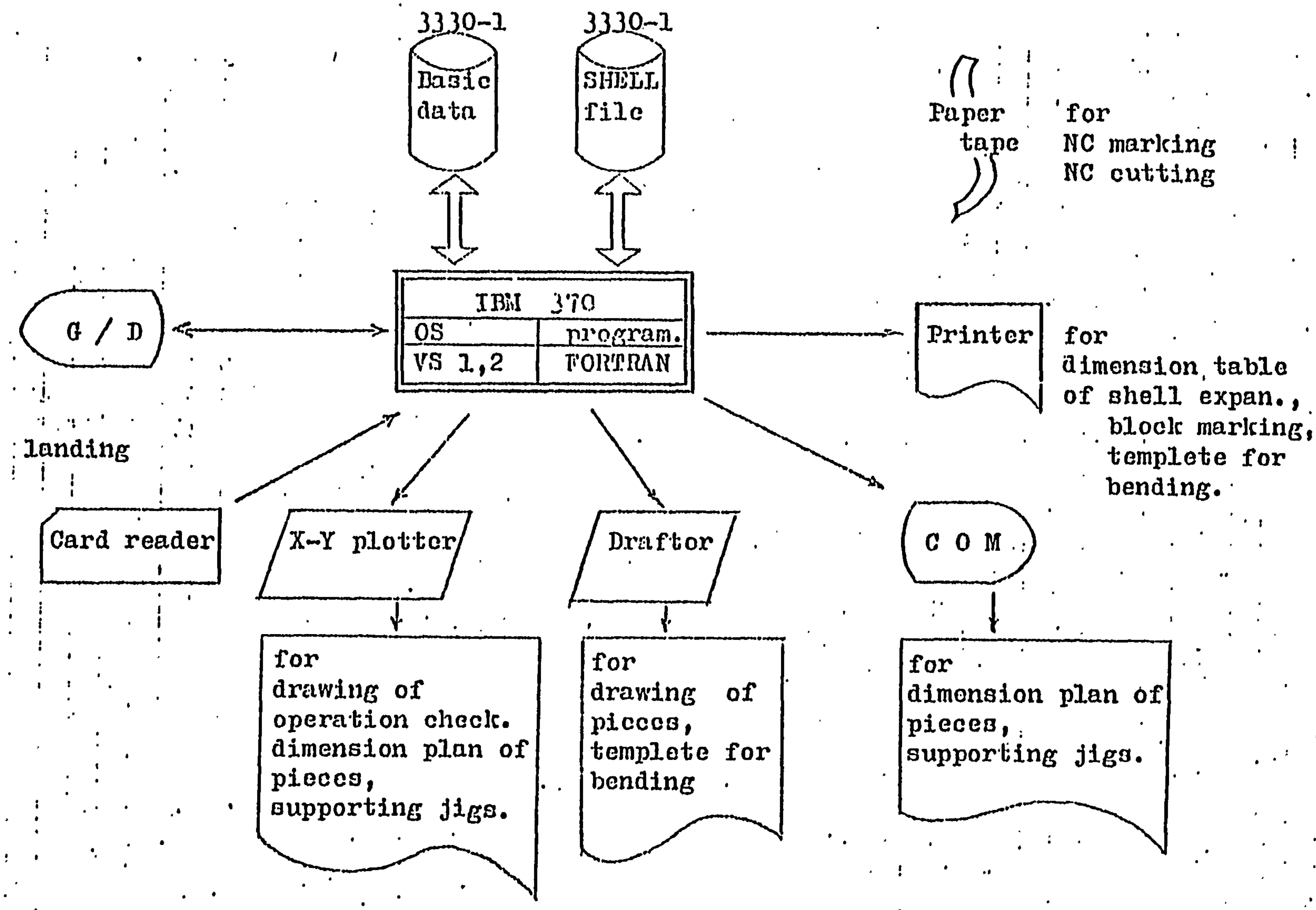
a) Graphic display
Available for shell landing.

b) X-Y plotter
Available for the piece drawing, dimension table in piece drawing, dimension table of the supporting jigs in, assembly stage, check drawing, etc..

c) Drafting machine
Available for drawings, to which higher accuracy of lines will be required such as a certain kinds of piece drawing, lines for templete making, etc.

d) COM:
Available for the dimension table of pieces, supporting jigs, etc...

Fig. 10 MAIN COMPUTOR AND ITS TERMINAL EQUIPMENTS



## 2-2 System Composition

### 2-2-l Data base

The most effective application of SHELL system in the processes of ship building field will primarily depend on how well the original offsets data file of the system can be prepared in the shortest time possible.- Shell landing to generate the offsets data should be advanced by the computor processing wherever possible, *&me the data base of the system requires the most accurated offsets data as an original data. *However, when the computer* processing shell landing is unavailable for the preparation of the data base, SHELL system so designed as to permit the system operation even through manual preparation of the offsets data.

1) Kinds of preparation methods

*a) FAIRLAND*

FAIRLAND system (fairing and landing system) *is avail-* . able for the preparation of the offsets data.

b) DACSSI/ S

The base data can be provided by the output from the offsets data file of DACSSI/S in which the offsets data are generated by means of conversational inputs with graphic display and/or input cards.

*c) Card* inputs from offsets table

The base data are provided directly by input cards in this system when it is required to process for the repaire ships and so on.

d) Conversion from the other systems

The base data are provided by the outputs of other systems through 2 certain conversion program.

2 ) Editting of base data

a) Editting method.

Editting on the sequential file in 80 columns card format

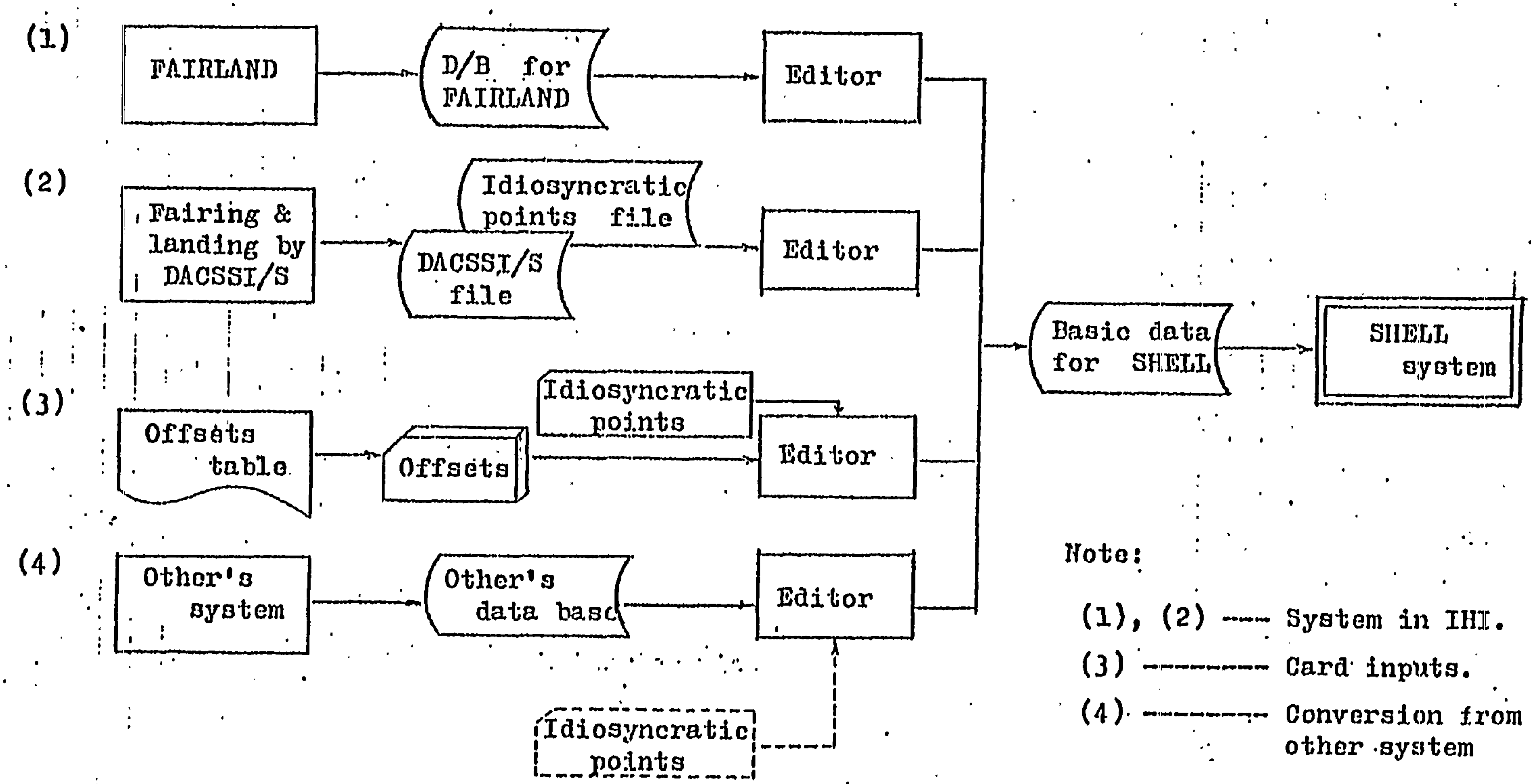
b) Access

SAM system is adopted to the access.

c) Data format

X——, Y——, Z——, pen, element, structural points, nature of points,

Fig: 10 PROCESS CHART FOR THE PREPARATION OF DATA BASE



2-2-2 System flow

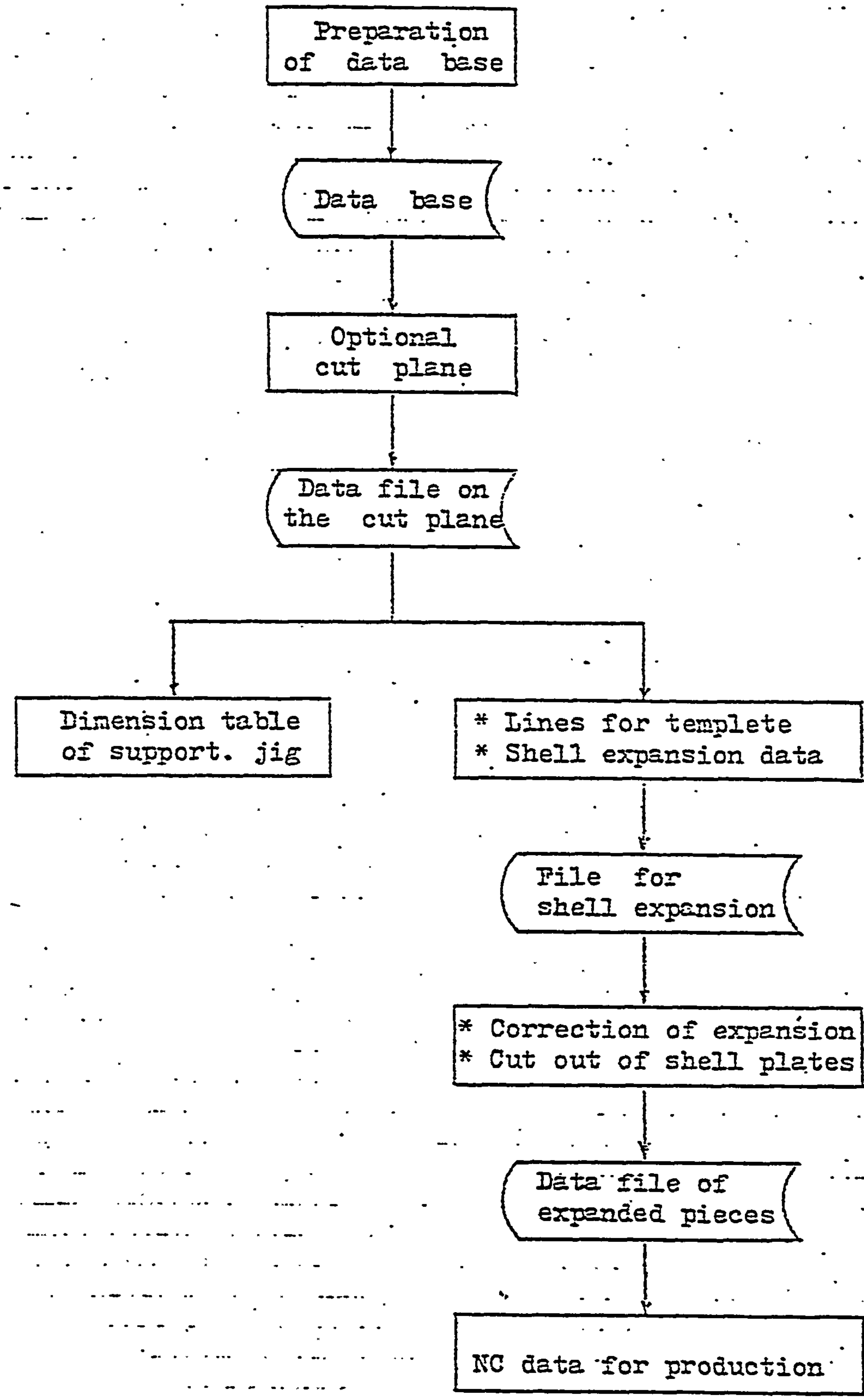


Table 1. STEPS INVOLVED IN SHELL SYSTEM

| Items \ Step | | Base data | Optional cut plane | Expansion | Calculations of Ass. data | Shape formation | Post processor |
|---|---|---|---|---|---|---|---|
| Input | | *Station offset<br>*Landing data<br>*Idiosyncratic points data<br>*Fabrication data (bevel, extension, etc) | *Block name<br>*Option for cut plane | *Method of shell expansion | *Type of supporting jigs | *Correction of fabrication data | *Piece name |
| Data process | | *Fairing & landing<br>*Storing of idiosyncratic points data & fabricat'n data | *Preparation of concurrence of points<br>*Preparation of data file on the cut plane | *Calculation of shell expansion<br>*Calculation of lines for bend. templetes | *Height of supporting jigs<br>*Dimension plan for block mark.<br>*Vector analysis plan | *Correction of shell expansion<br>*Cut out of shell plates | *NC post processor |
| File | Input | | *Base data file | *Data file on the cut plane | *Data file on the cut plane | *Shell expansion data file<br>*Fabrication data file | *Nesting data file |
| | Output | *Base data file | *Concurrence of points file<br>*Data file on the cut plane | *Shell expansion file<br>*Bending templete file | | *Nesting data file | |
| Output | | *Body plan<br>*Offsets table<br>*Check drawing of data base | *Rough block arrangement<br>*Body plan by optional cut plane | | *Dimension plan of support. jig<br>*Block mark. plan<br>*Sectional plan of support. jig<br>*Assembly plan | *Piece drawing<br>*Dimension plan of piece<br>*Lines for templetes making | *NC tape |

## 2-3 Input/Output system

### 2-3-1 Input data

The input data system in SHEEL is so designed as to conserve the labour by avoiding deplication of input data. Principal items of inputs are 2s fOllOws :

1) Name of block and structure
2) Instructive data relating to the fabrication practics.
3) Instructive data relating to the assembly practice.

### 2-3-2 Output data ( Other than NC tape for marking & cutting

1) Check drawing of the operation
   a) check drawing fo the data base ( fig.11A )
   b) Check drawing of body plan the optional 'cut plane (Fig. 1 l B )
   c) Sectional plan of supporting jigs. (fig. 12 )

   The check drawings in the above are using the check of the operation conditions of the outputs are in option controled by the inputs,

2) Output of shell expansion
   a) Dimention plan of shell plate
      Shell plate marking can be made directly by this output without any full scale marking tape the the manual marking. ( Fig. 13 )
   b) Expanded plan of shell plate
      negatives for the electrophoto marking are output by the' system by means of drafting machine as the expanded plan of shell plate, (Fig, 14)

Note: Outputs of the dimension table for the preparation of full scale marking tapes are also provided by this system, if required.

Fig. 11 A CHECK DRAWING OF DATA BASE

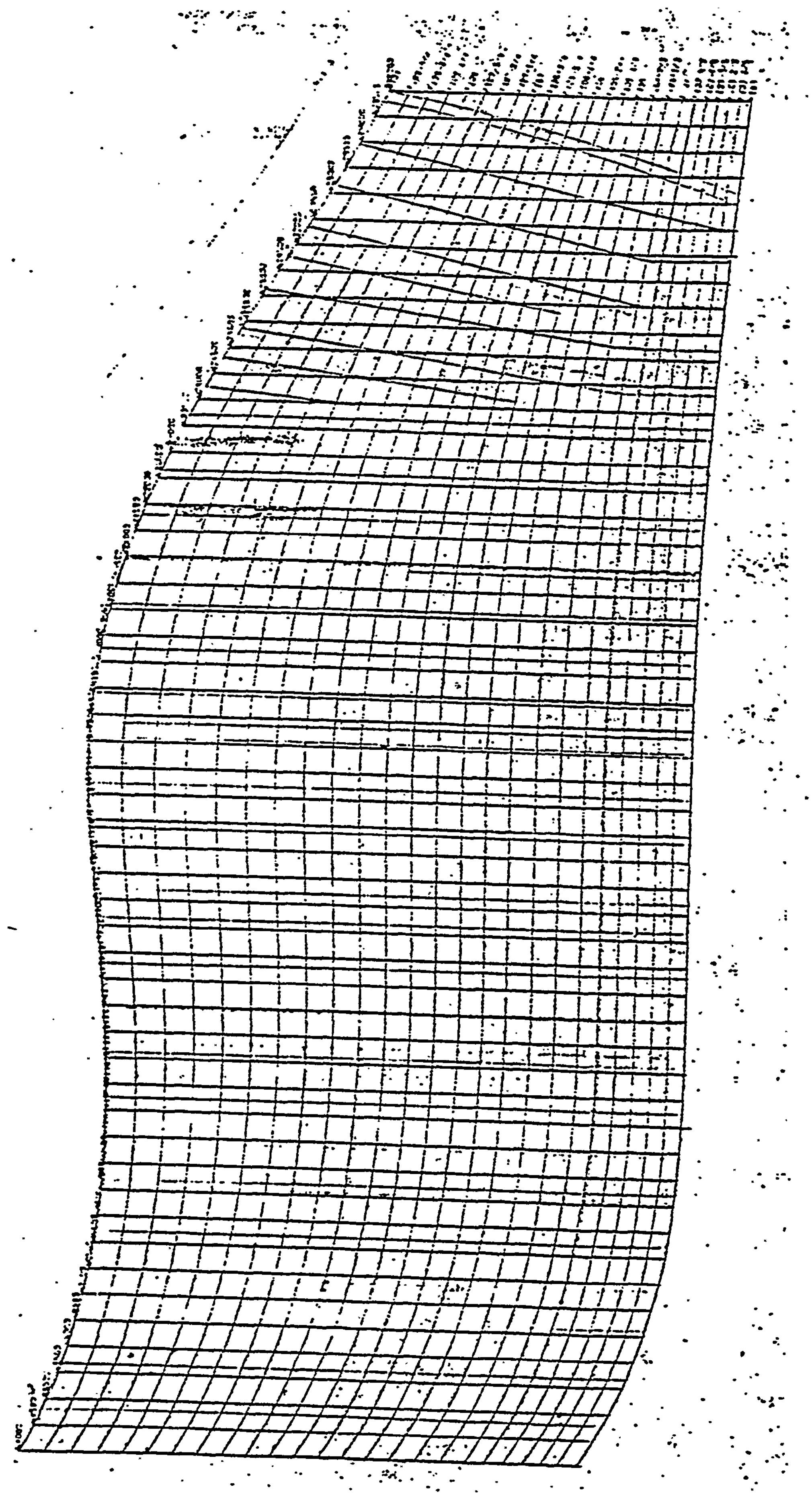


Fig. 11 B <u>CHECK DRAWING OF OPTIONAL CUT PLANE PROCESS</u>

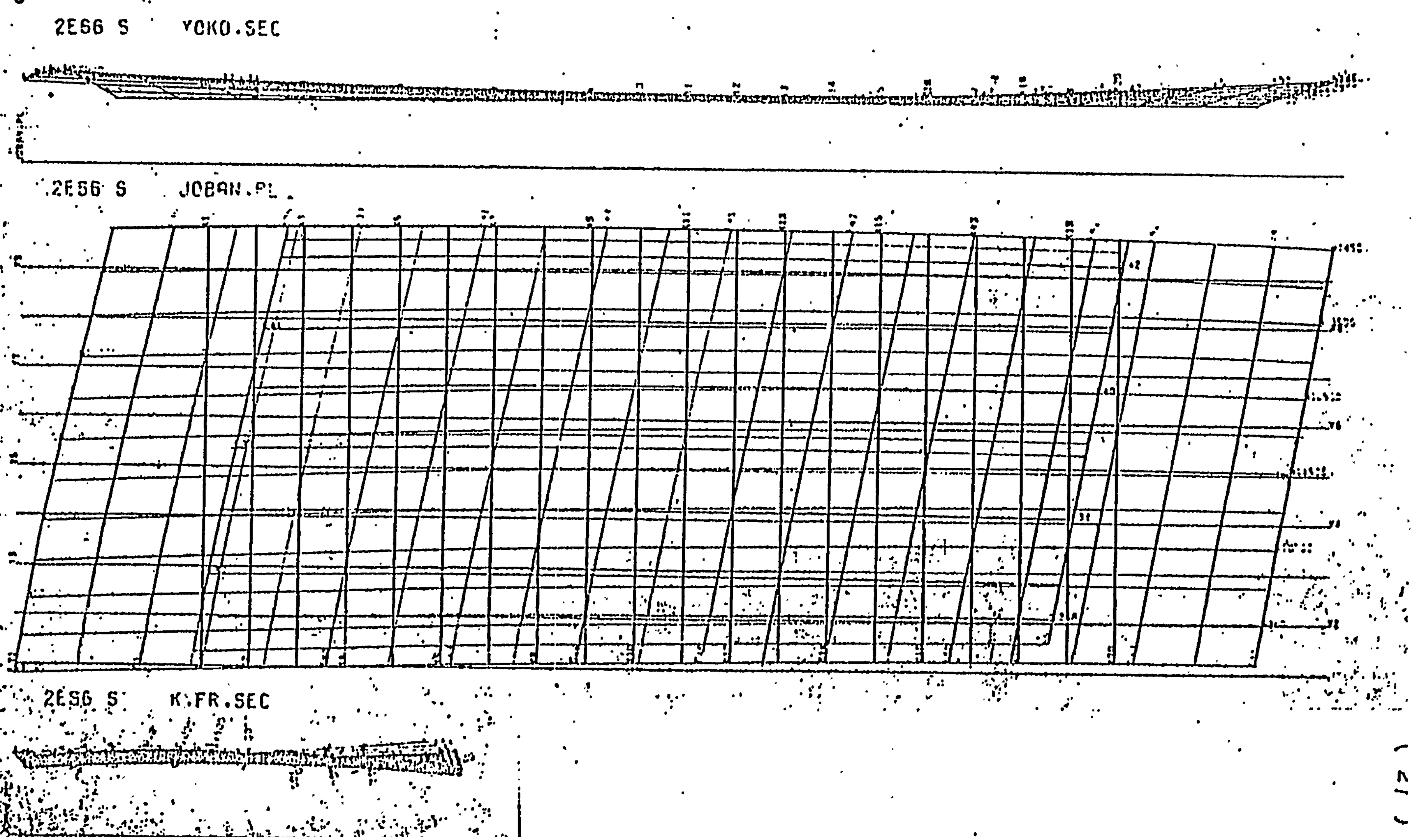


Fig. 12 SECTIONL PLAN OF SUPPORTING JIG LINE

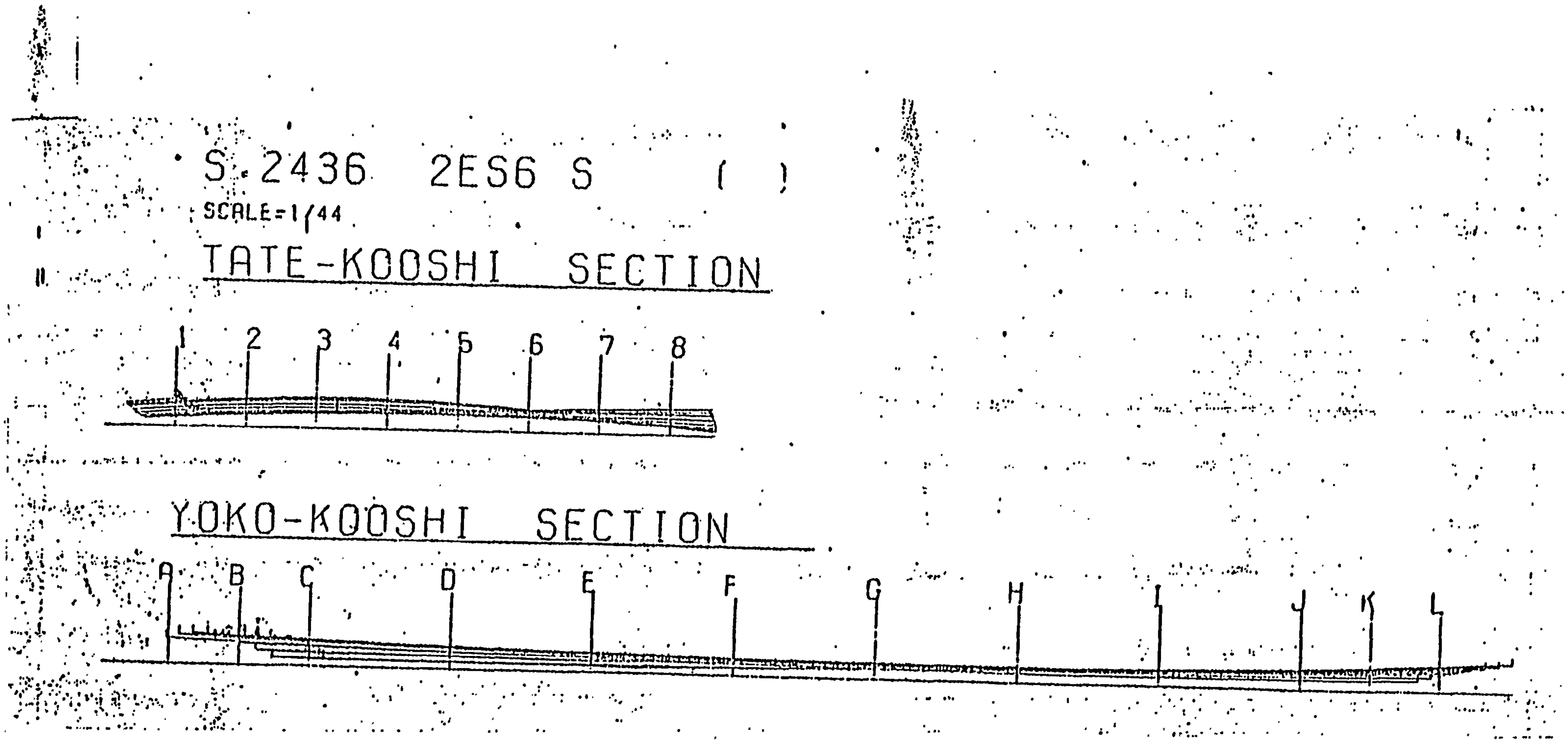


Fig. 13 DIMENSION PLAN OF SHELL PLATE

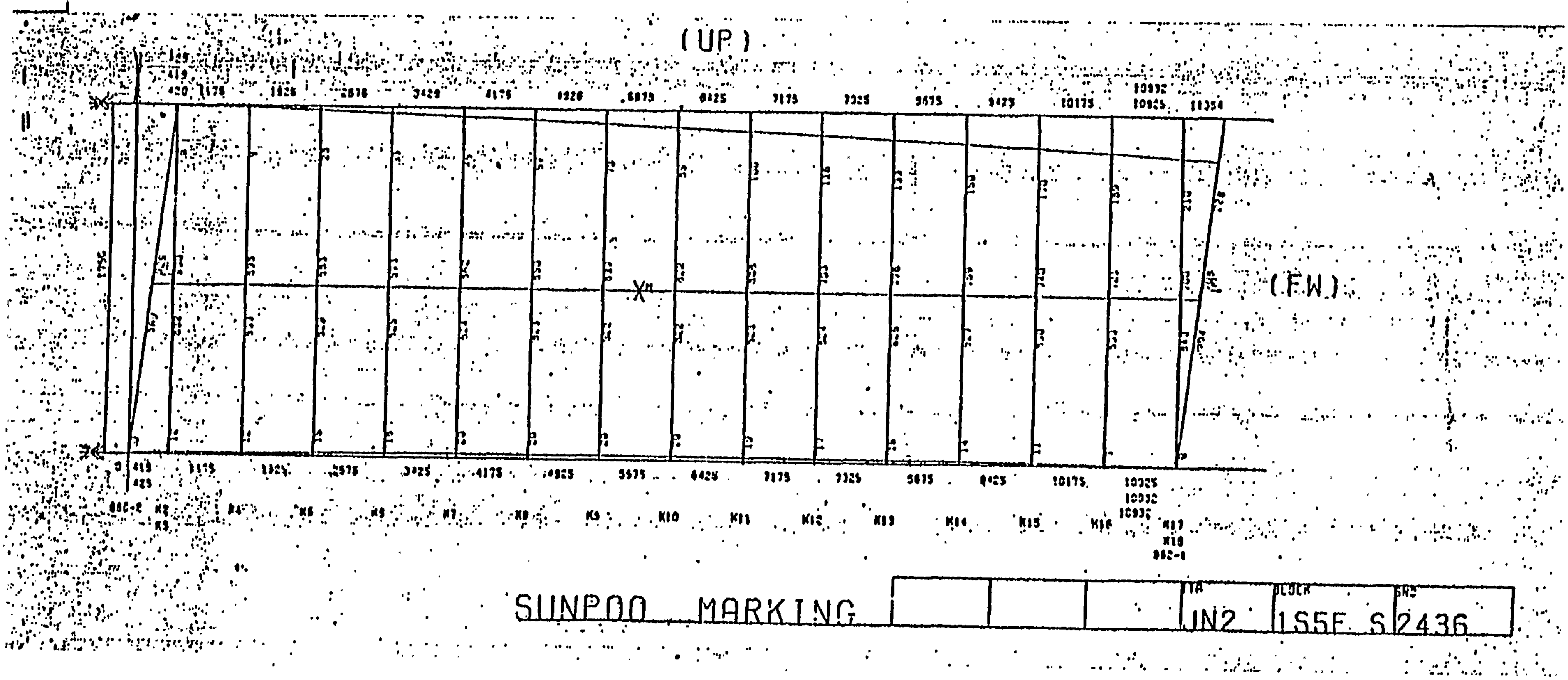
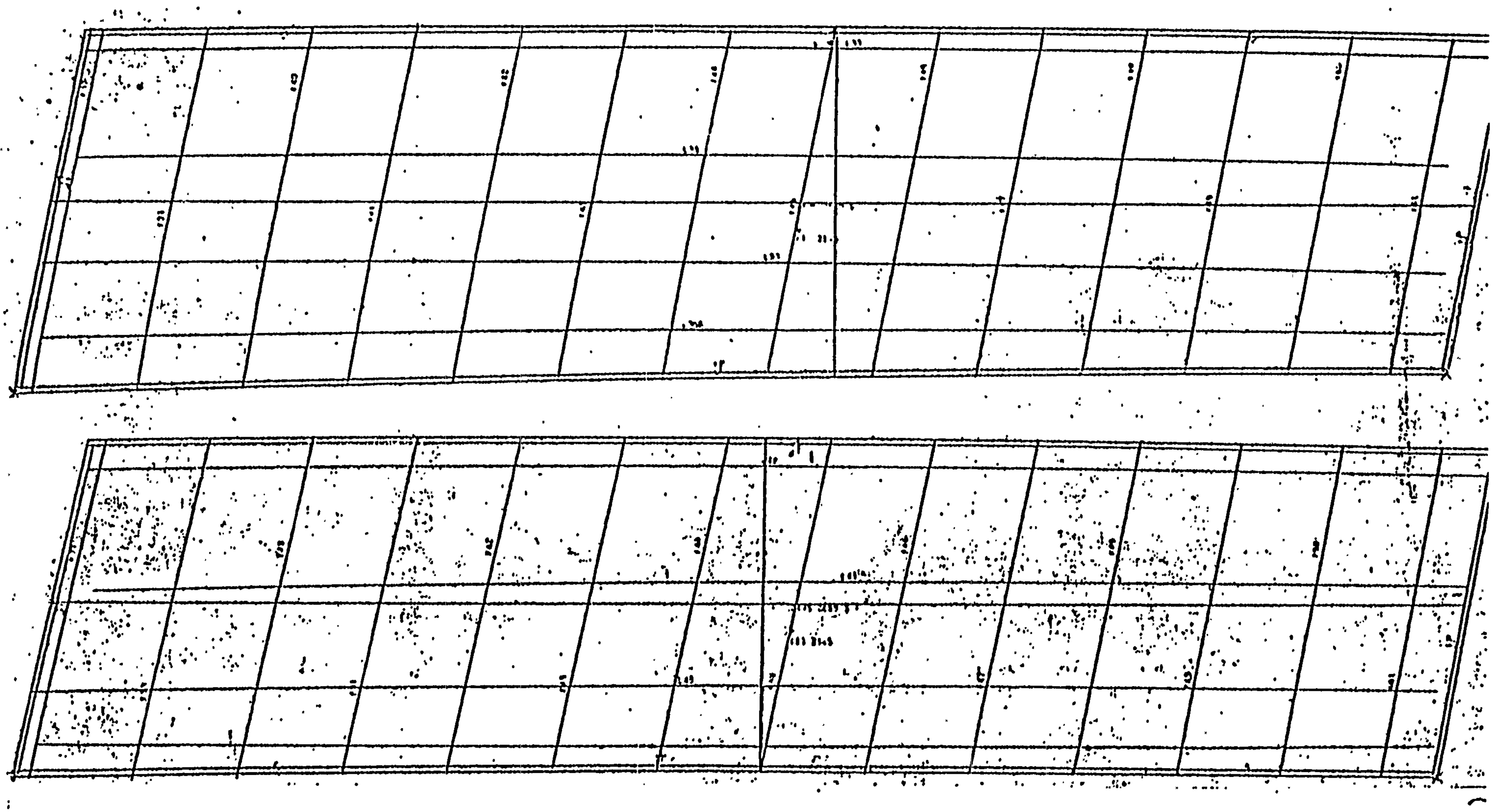


Fig. 14 EXPANDED PLAN OF SHELL PLATE



3) Output of templete for bending

a) Lines for templetes marking

The most optimum position determined by a given logic as well as the shape (lines) of templetes at 2 designated position are prepared by means of lines drawn by draftor. (Fig.15)

b) Dimension table for universal templete

When a certain type of universal templete are available in the shop, suitable dimension table can be provided by the system to set the figure of the templete. ( Table 2 )

4) output data for supporting jigs in assembly

The output mode of Sheel system is diversified into various modes owing to the inclusion of data relating to the type of supporting jigs as well as the data relating to the methods of block marking. The users can therefore,'select any desirable output met to the working practices to be done.

a) Dimension plan.for block supporting jigs.

* For fixed position jigs * ( fig. 16 )
* For seam line jigs ( fig. 17 )
* For frame line jigs (Fig.18)
* For SINGLE system jigs ( fig.19)
* For solid tape jigs

While the five kinds of dimension plans, listed above, are avai1able, they can be used also in combinatinon, if necessary.

b) Sectional plan of jig lines (Fig.20)

Sectional plan of jig lines can be drafted t0 indicate the curvetures at the transverse or longi-tudinal section of jig lines including the ends height of the block at the cross points of jig line; and seam or butt line of the block, if required.

Fig. 15 LINES FOR BENDING TEMPLETE MAKING

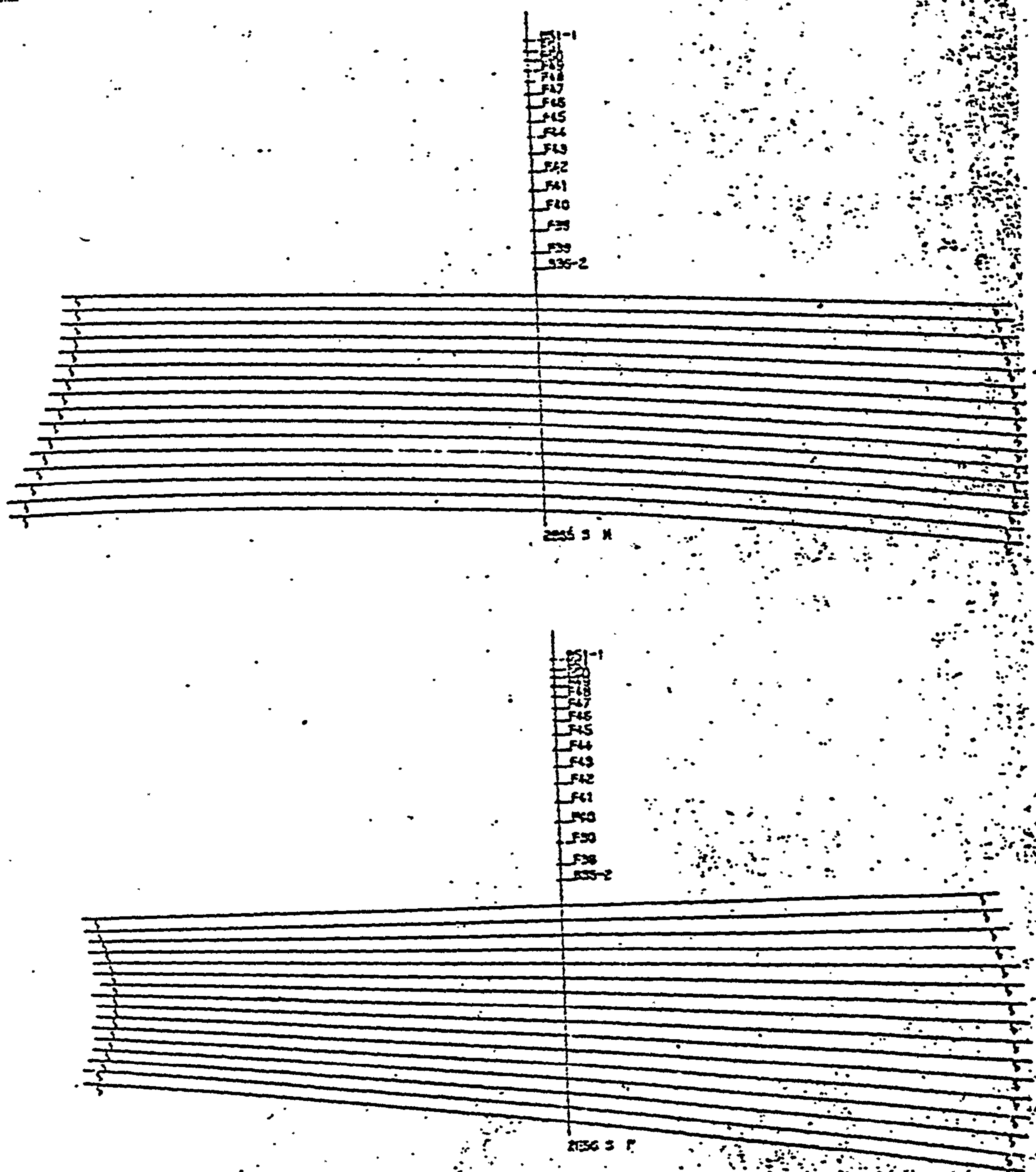


Table 2. DIMENSION TABALE FOR UNIVERSAL TEMPLETE

| FRAME | H.N | M.H | L.L | L.SH | A | B | C | D | E | F | G | H | I | J | K | U.SH | E.N | U.L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B115-2 | G | 1302 | 131 | 326 | 300 | 341 | 377 | 407 | 430 | 446 | *459 | 464 | 463 | 456 | 444 | 452 | J | 152 |
| K3 | F | 1390 | 270 | 318 | 312 | 338 | 357 | 369 | 373 | *373 | 365 | 350 | 329 | 300 | | 316 | I | 123 |
| K4 | F | 1344 | 214 | 314 | 310 | 336 | 355 | 353 | 372 | *372 | 365 | 350 | 329 | 300 | | 315 | I | 129 |
| K5 | F | 1308 | 179 | 309 | 301 | 324 | 346 | 362 | 368 | *368 | 362 | 348 | 328 | 300 | | 311 | I | 169 |
| K6 | F | 1267 | 148 | 312 | 300 | 326 | 349 | 364 | 372 | *372 | 367 | 355 | 335 | 308 | | 315 | I | 203 |
| K7 | F | 1227 | 121 | 315 | 300 | 320 | 351 | 365 | 375 | *376 | 371 | 360 | 341 | 316 | | 318 | I | 231 |
| K8 | F | 1134 | 96 | 326 | 309 | 335 | 362 | 375 | 387 | *389 | 385 | 374 | 357 | 332 | 300 | 321 | J | 6 |
| K9 | F | 1140 | 79 | 325 | 304 | 333 | 357 | 374 | 384 | *386 | 393 | 372 | 355 | 331 | 300 | 326 | J | 25 |
| K10 | F | 1095 | 64 | 327 | 305 | 335 | 358 | 375 | 385 | *388 | 335 | 375 | 355 | 334 | 300 | 330 | J | 39 |
| K11 | F | 1046 | 54 | 325 | 300 | 331 | 356 | 373 | 384 | *387 | 384 | 374 | 357 | 334 | 300 | 328 | J | 48 |
| K12 | F | 1000 | 47 | 326 | 300 | 331 | 356 | 373 | 384 | *387 | 395 | 375 | 358 | 334 | 303 | 328 | J | 52 |
| K13 | F | 950 | 45 | 326 | 300 | 331 | 356 | 373 | 384 | *327 | 385 | 374 | 358 | 334 | 302 | 328 | J | 52 |
| K14 | F | 900 | 46 | 327 | 301 | 332 | 356 | 374 | 384 | *387 | 384 | 374 | 356 | 332 | 300 | 327 | J | 47 |
| K15 | F | 848 | 52 | 332 | 307 | 337 | 362 | 379 | 389 | *392 | 389 | 378 | 360 | 335 | 300 | 331 | J | 37 |
| K16 | F | 794 | 62 | 333 | 309 | 339 | 363 | 380 | 393 | *392 | 388 | 377 | 358 | 333 | 300 | 330 | J | 22 |
| K17 | F | 739 | 75 | 339 | 317 | 347 | 370 | 386 | 396 | *397 | 392 | 380 | 361 | 334 | 300 | 334 | J | 2 |
| K18 | F | 682 | 93 | 320 | 300 | 330 | 353 | 368 | 377 | *377 | 372 | 359 | 338 | 310 | | 313 | I | 228 |
| K19 | F | 624 | 115 | 317 | 300 | 329 | 351 | 366 | 373 | *373 | 367 | 353 | 331 | 301 | | 309 | I | 198 |
| K20 | F | 564 | 140 | 324 | 310 | 338 | 359 | 373 | 378 | *378 | 371 | 355 | 332 | 300 | | 313 | I | 165 |
| K21 | F | 503 | 170 | 331 | 321 | 348 | 368 | 380 | 385 | *383 | 374 | 357 | 332 | 300 | | 317 | I | 127 |
| K22 | F | 440 | 203 | 340 | 335 | 361 | 379 | 390 | 393 | *390 | 379 | 360 | 334 | 300 | | 324 | I | 84 |
| K23 | F | 376 | 240 | 350 | 349 | 373 | 390 | 400 | 401 | *397 | 384 | 364 | 336 | 300 | | 331 | I | 37 |
| K24 | G | 346 | 8 | 355 | 324 | 356 | 360 | 397 | 405 | 407 | *401 | 388 | 366 | 337 | 300 | 335 | J | 15 |
| B118-1 | G | 315 | 207 | [illegible] | 300 | 341 | 376 | 405 | 424 | 446 | *457 | 462 | 462 | 457 | 445 | 454 | J | 97 |

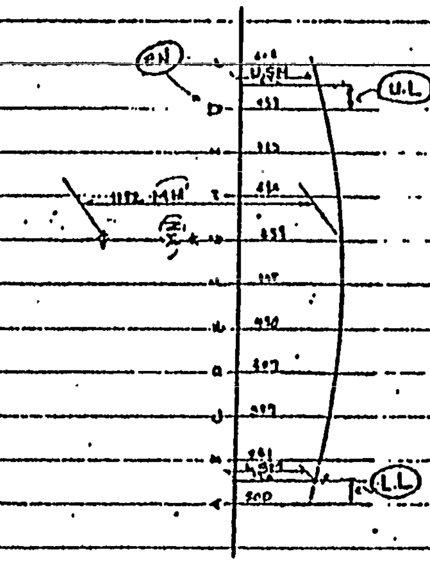
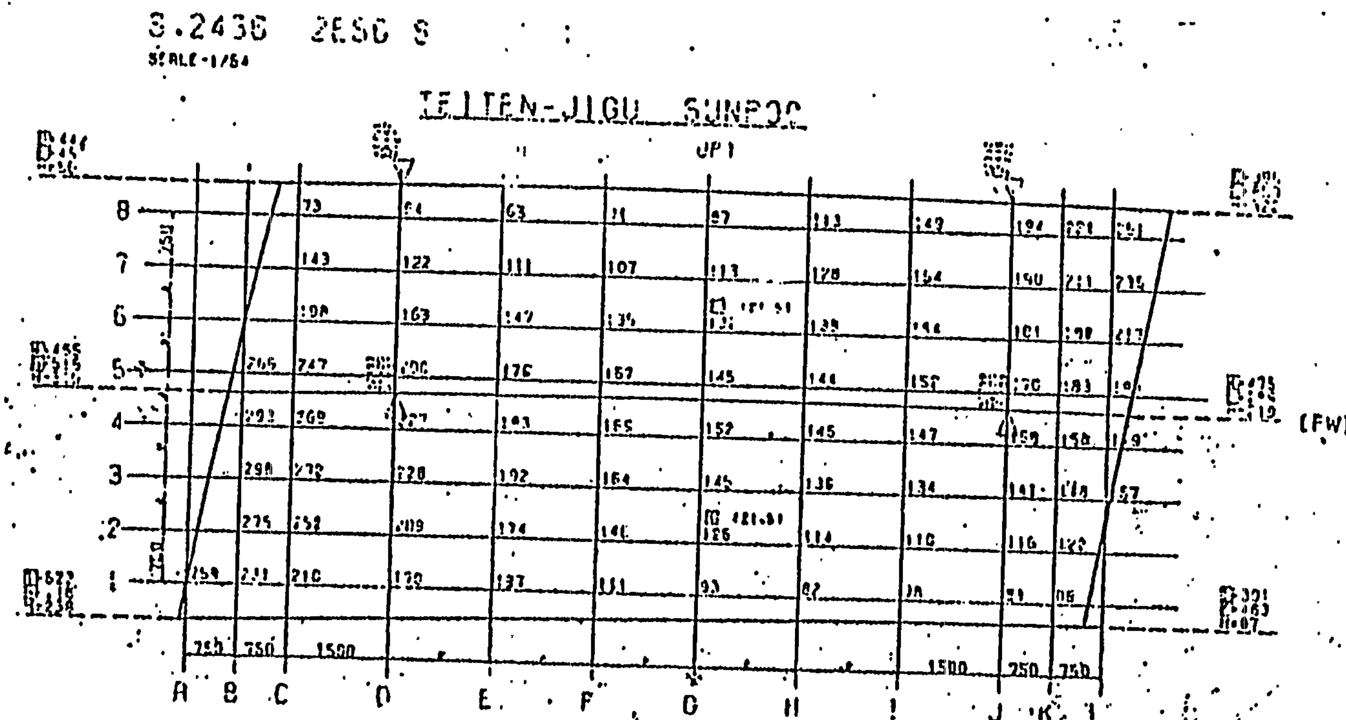


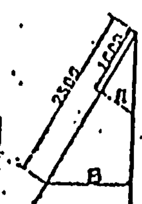
Fig. 16 DIMENSION PLAN FOR FIXED POSITION JIGS




IBLOCK SIZE= 9253 * 144871

TRANS FURISAGE-DO

| SLANT-DIR. | KAKUDO | A | B |
|---|---|---|---|
| A | 17.8 | 321 | 765 |



TRANS TORITUKE-DO

| FR.NO | TYPE | (L) | (K) | (H) |
|---|---|---|---|---|
| F40 | A | 69.8 | 71.2 | 79.4 |
| F44 | A | 70.6 | 71.8 | 73.7 |
| F47 | A | 71.2 | 72.3 | 74.0 |

Fig. 17 DIMENSION PLAN FOR SEAM LINE JIGS

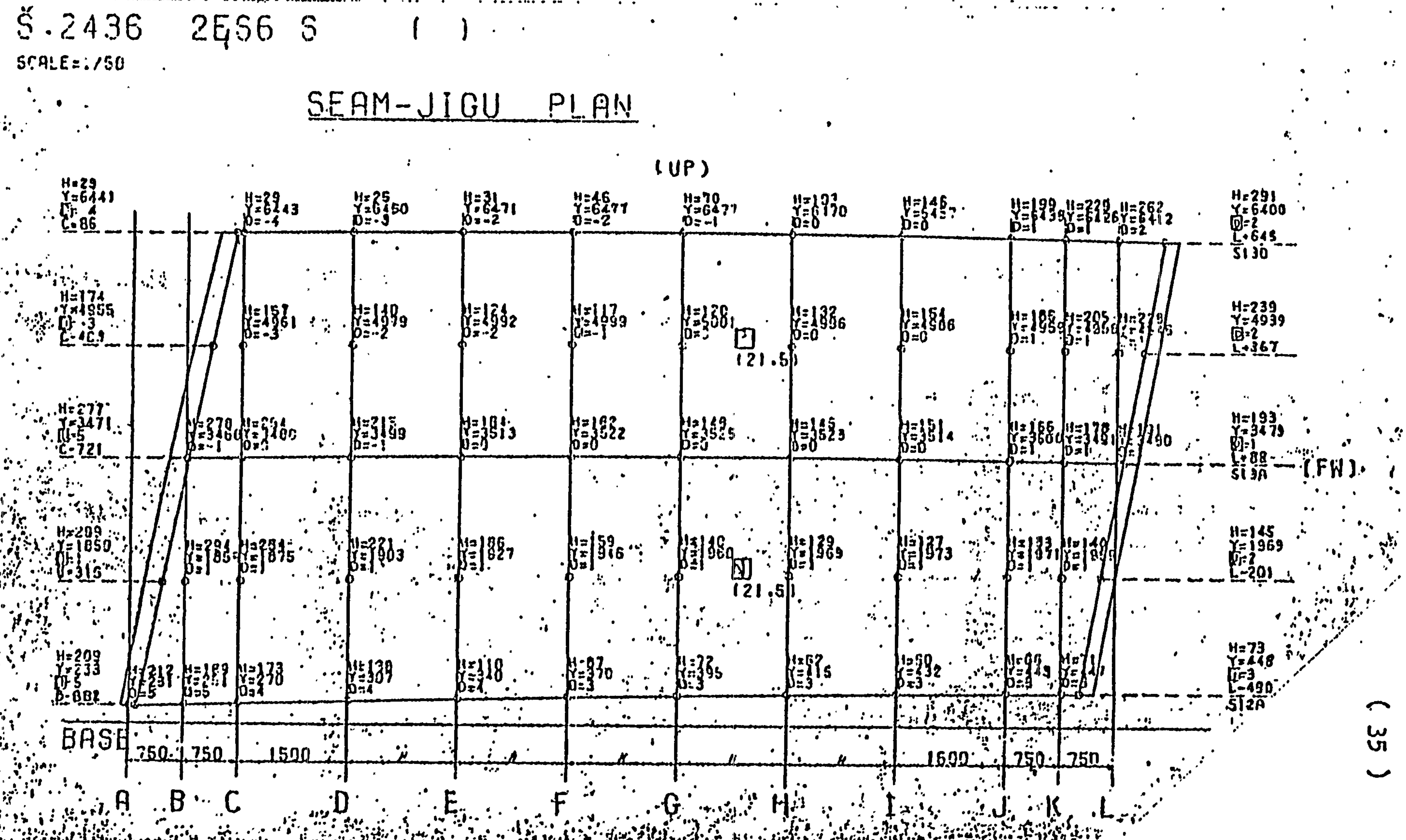


Fig. 18 DIMENSION PLAN FOR FRAME LINE JIGS

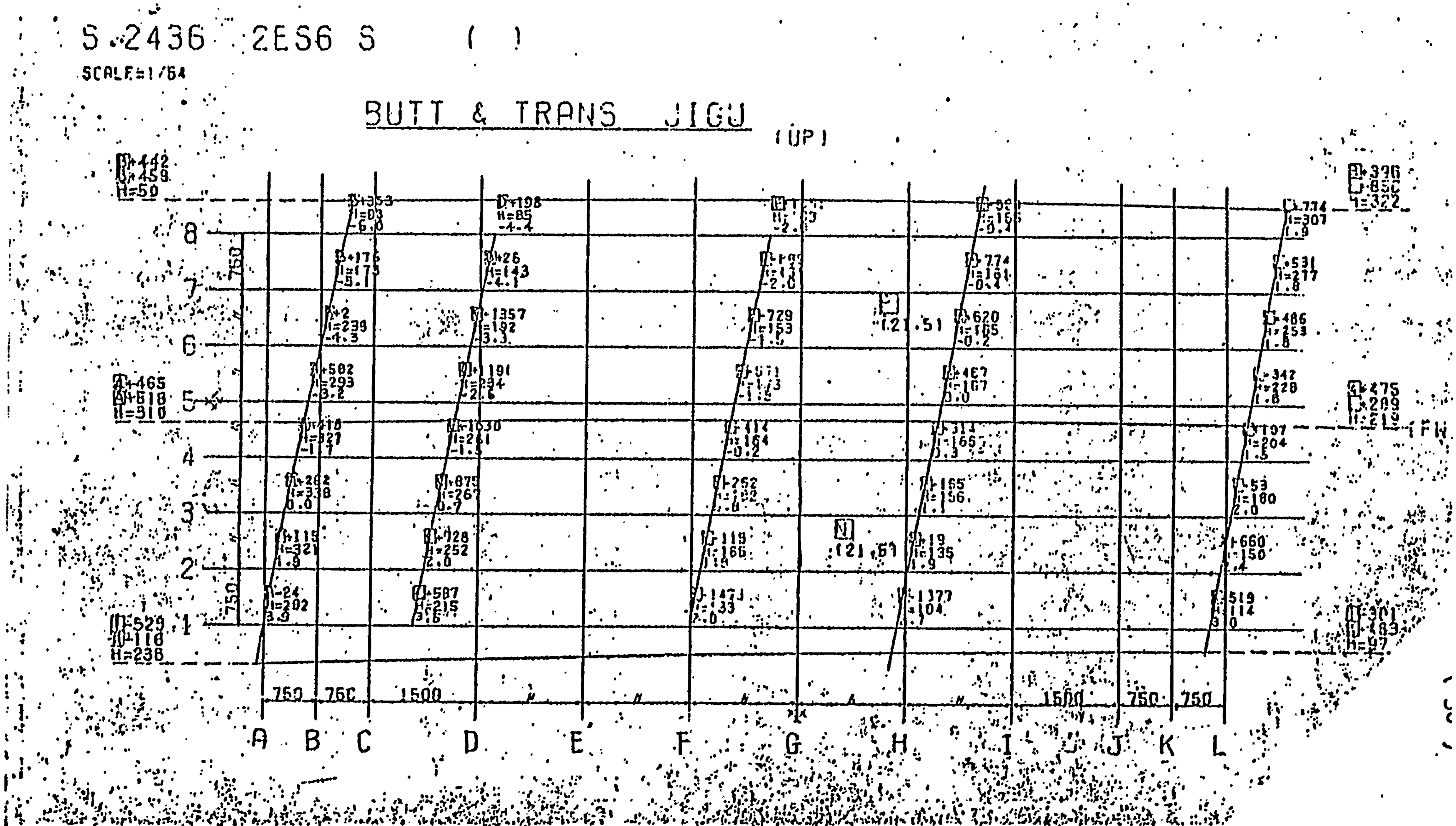
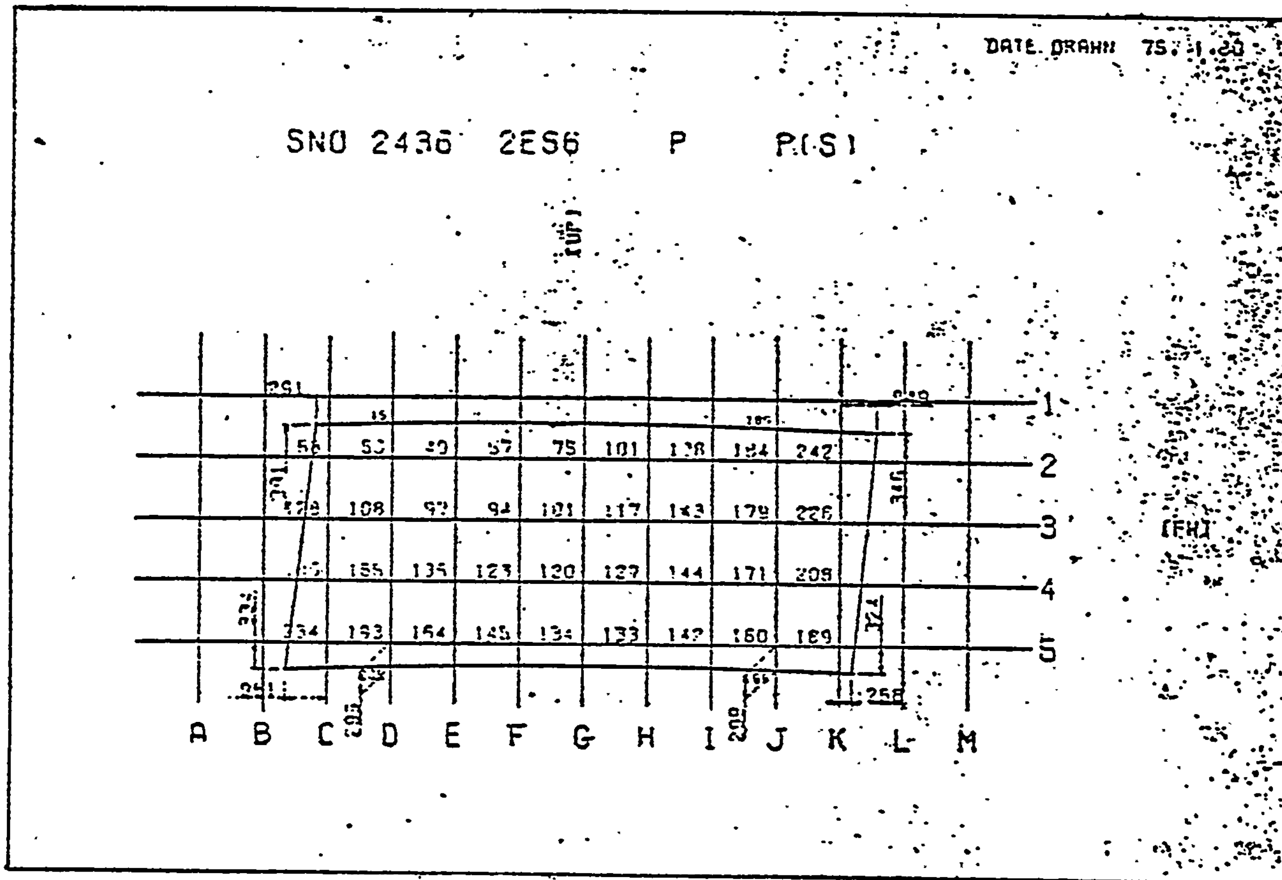


Fig. 19 DIMENSION PLAN FOR SINGLE PANEL SYSTEM



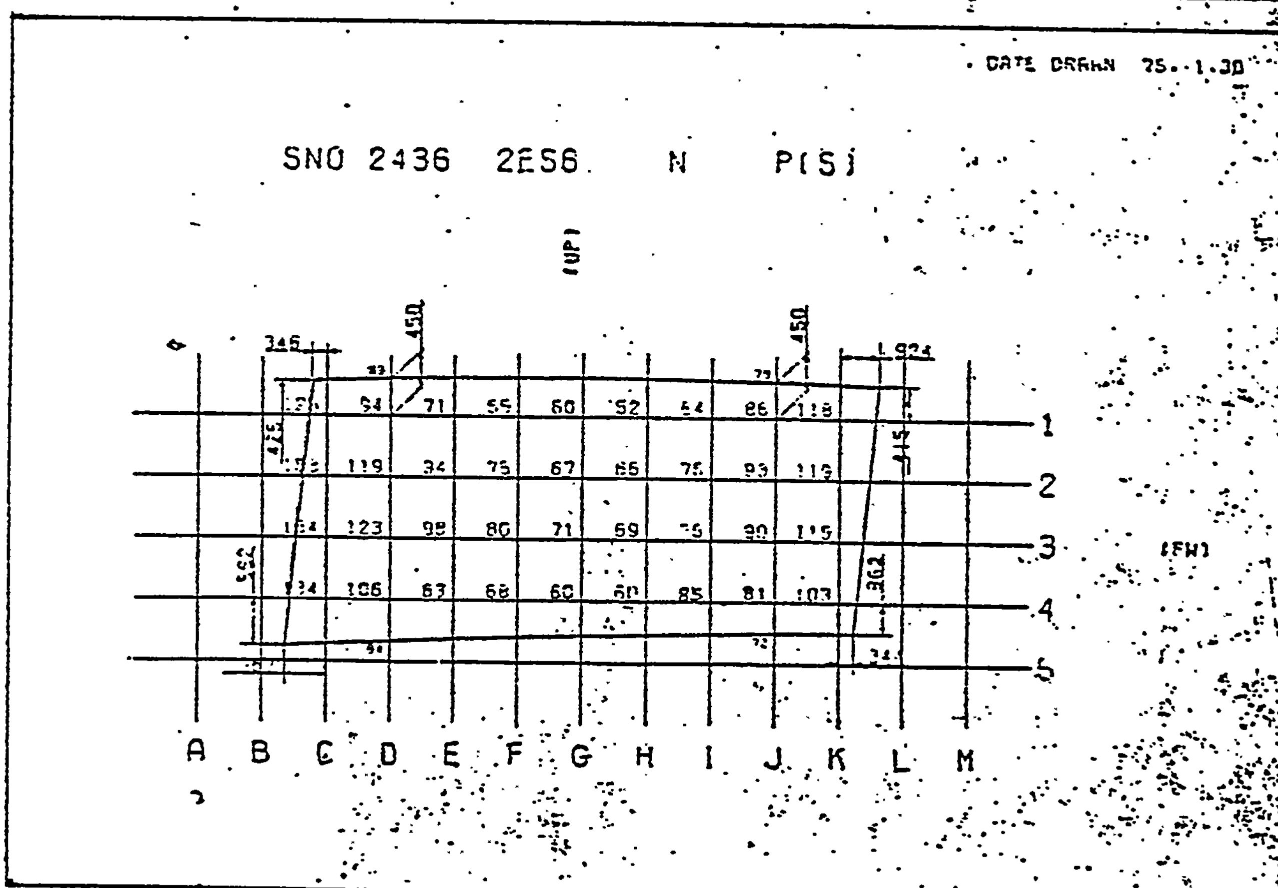
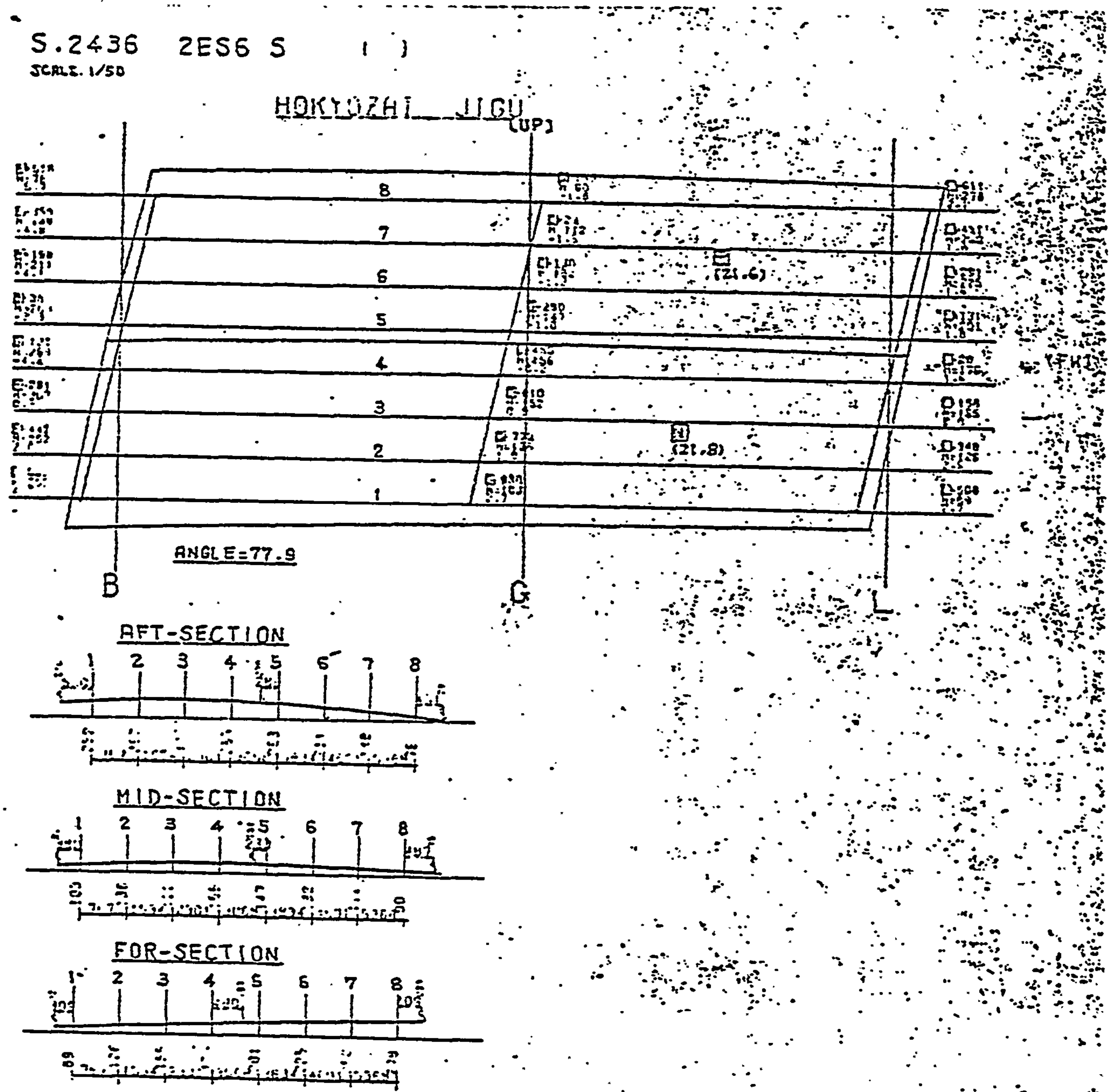



Fig. 20 SECTIONAL PLAN OF JIG LINES



5) Dimension table for block marking

The dimension table for the block marking is printed out by the system and full scale marking tape can be made from the output in mould loft. In the dimension table, length and with of the block are shown on the frame lines either of ordinally and optional cut plane.

Block marking is made using-the transverse and longitudinal datum lines on the block. Since those datum lines are marked on the each shell plate of the block in beforehand, easier working procedures will be expected to maintain the accuracy, so far as the previous stages are keeping their accuracy in the torelance.

6) Check data for the automatic welding

The maximum slope of the seam lines against ground level are output in the vectoral indication to check the availability of automatic welding on the block.

7) Accuracy control data

a) Geometrical check of block

Dimension plan is provided for the accuracy control of geometrical form of the block.

b) Positionning of materials

Data relating to the size of shell plate and location of the positionning jig for the shell plate are indicated in the dimension table of supporting jigs. These data will be available to secure the right position of Shell plate on the platform and it ensure the geometrical form of block.

c) Datum planes

The datum planes for the block marking are orthonally mutually and also to the platform plane.

It means that working condition is better for the ensuring of block accuracy.

## Table 3 DIMENSION TABLE FOR BLOCK MARKING

( Ordinary frame )

| (LINE-NAME) | [illegible] | [illegible] | [illegible] | F38 | F39 | F40 | F41 | F42 | F43 | F44 | F45 | F46 | F47 | F48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L42 | 7621 | 7621 | 1268 | 1429 | 2399 | 33.7 | 4333 | 5293 | 6261 | 7222 | 8192 | 9159 | 10035 | 11049 |
| L41 | ($a_1$) 7621 | ($a_2$) 7621 | ($a_3$) 1010 | ($a_4$) 1172 | ($a_5$) 2148 | ($a_6$) 3122 | ($a_7$) 4094 | ($a_8$) 5064 | ($a_9$) 6032 | ($a_{10}$) 6998 | ($a_{11}$) 7962 | ($a_{12}$) 8925 | ($a_{13}$) 9885 | ($a_{14}$) 10843 |
| L40 | 7621 | 7621 | 803 | 966 | 1944 | 2920 | 3893 | 4864 | 5834 | 6802 | 7769 | 8733 | 9695 | 10655 |
| L39 | 7621 | 7621 | 597 | 761 | 1740 | 2717 | 3691 | 4664 | 5636 | 6605 | 7573 | 8539 | 9503 | 10465 |
| L38 | 7621 | 7621 | 398 | 562 | 1541 | 2517 | 3493 | 4466 | 5438 | 6409 | 7377 | 8344 | 9309 | 10273 |
| L37 | 7621 | 7421 | 211 | 375 | 1353 | 2329 | 3304 | 4277 | 5249 | 6219 | 7188 | 8155 | 9121 | 10085 |
| L36A | 7621 | 7621 | 67 | 251 | 1230 | 2208 | 3184 | 4159 | 5132 | 6104 | 7074 | 8043 | 9011 | 9978 |
| S13D | ($b_1$) 7621 | ($b_2$) 7621 | ($b_3$) 1329 | ($b_4$) 1490 | ($b_5$) 2459 | ($b_6$) 3426 | ($b_7$) 4390 | ($b_8$) 5354 | ($b_9$) 6315 | ($b_{10}$) 7275 | ($b_{11}$) [illegible] | ($b_{12}$) [illegible] | ($b_{13}$) 10145 | ($b_{14}$) 11098 |
| S13A | 7621 | 7621 | 637 | 801 | 1779 | 2756 | 3731 | 4704 | 5675 | 6644 | 7611 | 8577 | 9541 | 10503 |
| S12A | 7621 | 7621 | 0 | 164 | [illegible] | 2122 | 3099 | 4075 | 5050 | 6023 | 6995 | 7966 | 8936 | 9904 |
| L.KOSHI } 一致 | ($c_1$) 7621 | ($c_2$) 7621 | ($c_3$) 701 | ($c_4$) 864 | ($c_5$) 1838 | ($c_6$) 2812 | ($c_7$) 3784 | ($c_8$) 4754 | ($c_9$) 5723 | ($c_{10}$) 6691 | ($c_{11}$) 7659 | ($c_{12}$) 8624 | ($c_{13}$) 9588 | ($c_{14}$) 10551 |
| L.KISEN | 7621 | 7621 | 701 | 864 | 1838 | 2812 | 3783 | 4754 | 5723 | 6691 | 7658 | 8624 | 9588 | 10551 |

Fig. 21 EXPLANETORY PLAN OF Table 3.

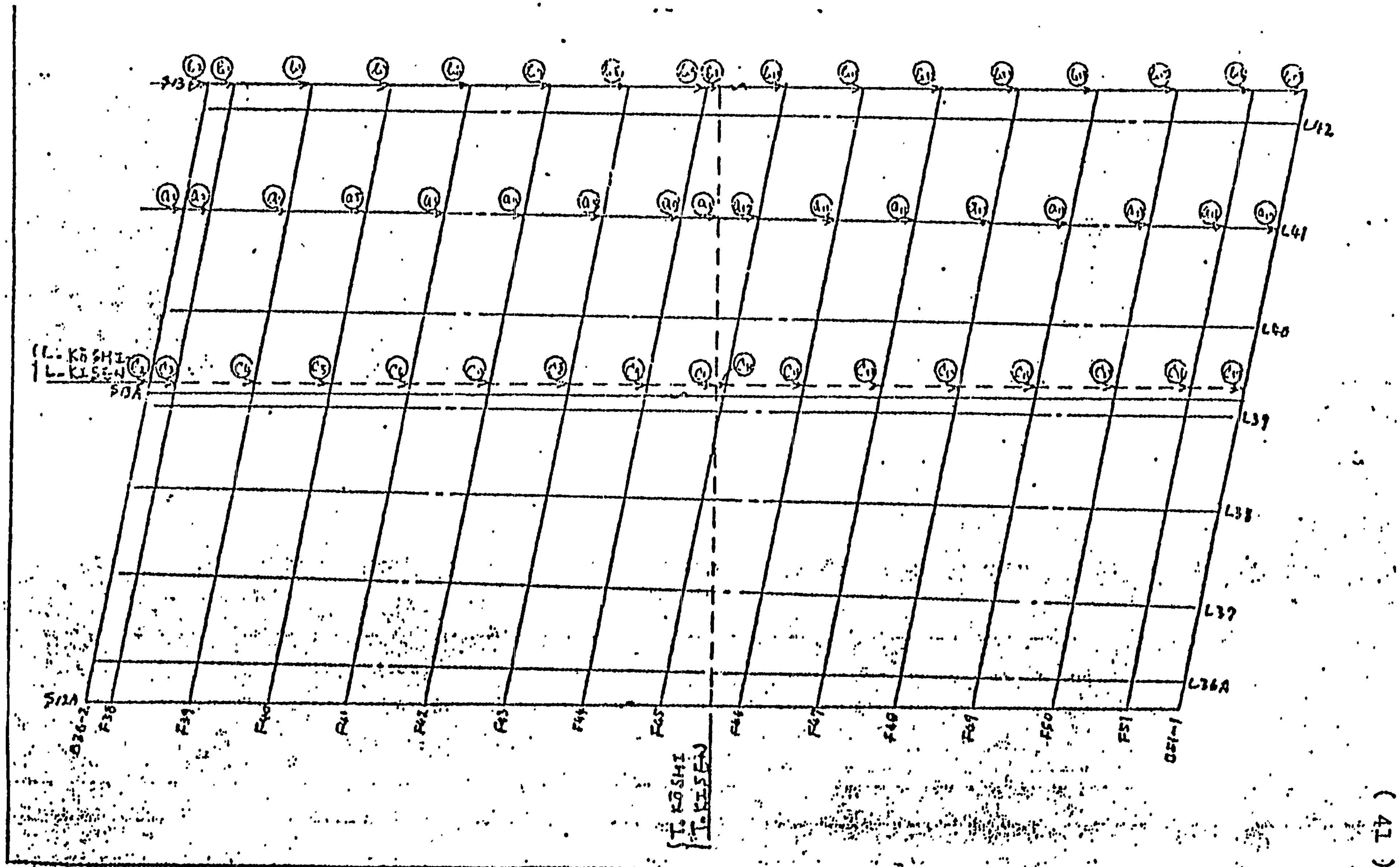


Table 4 DIMENSION TABLE FOR BLOCK MARKING

( Cut plane frame base )

( NAGASA SUMPOU ) KIRINAOSHI FRAME

一致

| LINE-NAME | KISEN | KOSHI | K2 | K3 | K4 | K5 | K6 | K7 | K8 | K9 | K10 | K11 | K12 | K13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L42 | 7621 | 7621 | ***** | 1621 | 2371 | 312. | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L41 | 7621 | 7621 | ***** | 1620 | 2370 | 3121 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L40 | 7621 | 7621 | 869 | 1620 | 2370 | 3120 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L39 | 7621 | 7621 | 869 | 1620 | 2370 | 3120 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L38 | 7621 | 7621 | 869 | 1619 | 2370 | 3120 | 3870 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L37 | 7621 | 7621 | 869 | 1620 | 2370 | 3120 | 3870 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L36A | 7621 | 7621 | 869 | 1619 | 2370 | 3120 | 3870 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| S13D | 7621 | 7621 | ***** | 1621 | 2371 | 3121 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| S13A | 7621 | 7621 | 869 | 1620 | 2370 | 3120 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| S12A | 7621 | 7621 | 869 | 1619 | 2369 | 3120 | 3870 | 4620 | 5370 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L.KOSHI 一致 | 7621 | 7621 | 870 | 1620 | 2370 | 3121 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |
| L.KISEN | 7621 | 7621 | 870 | 1620 | 2370 | 3120 | 3871 | 4621 | 5371 | 6121 | 6871 | 7621 | 8371 | 9121 |

Fig. 22 EXPLANETORY PLAN OF Table 4.

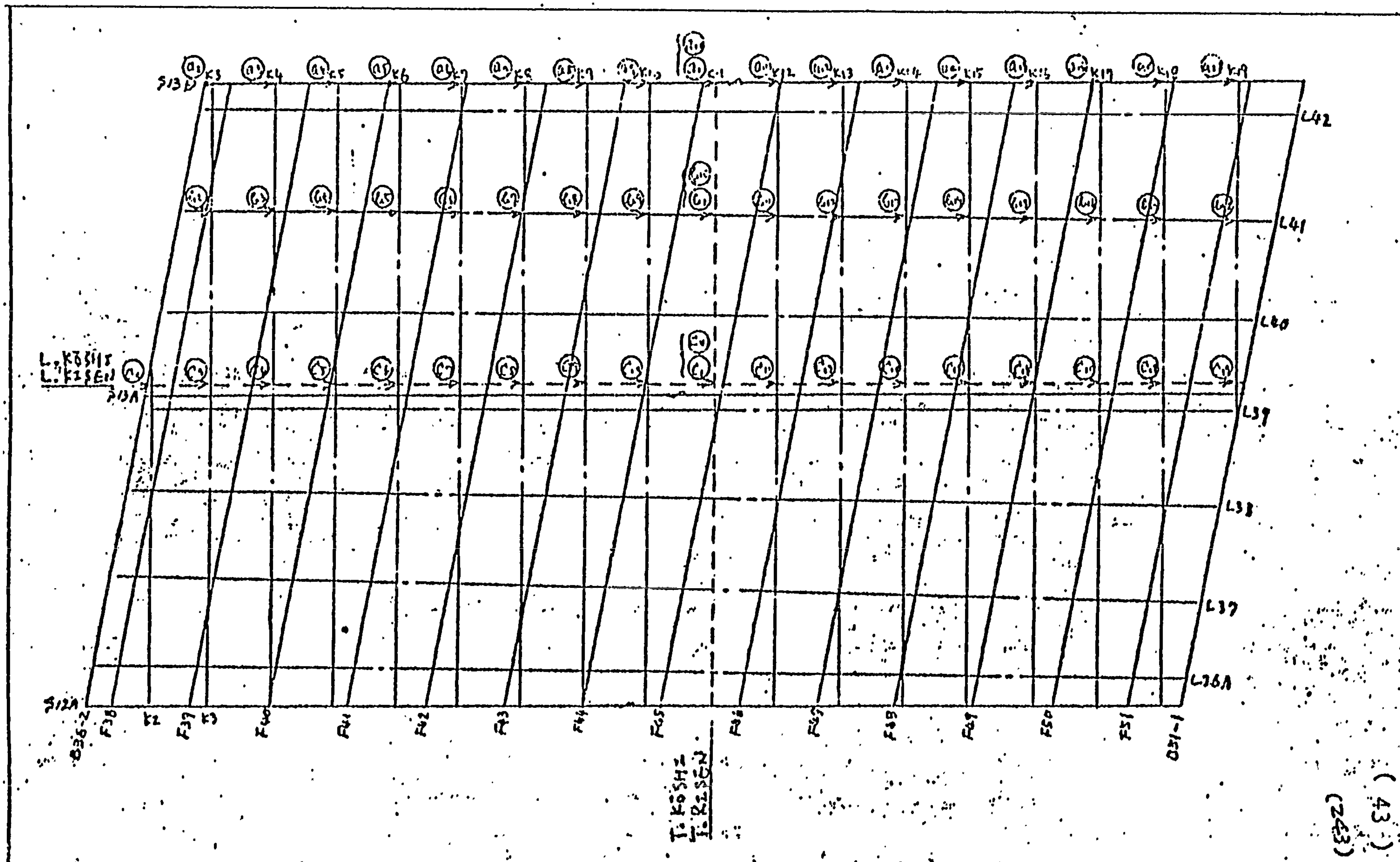


Fig. 23 CHECK DATA FOR AUTOMATIC WELDING

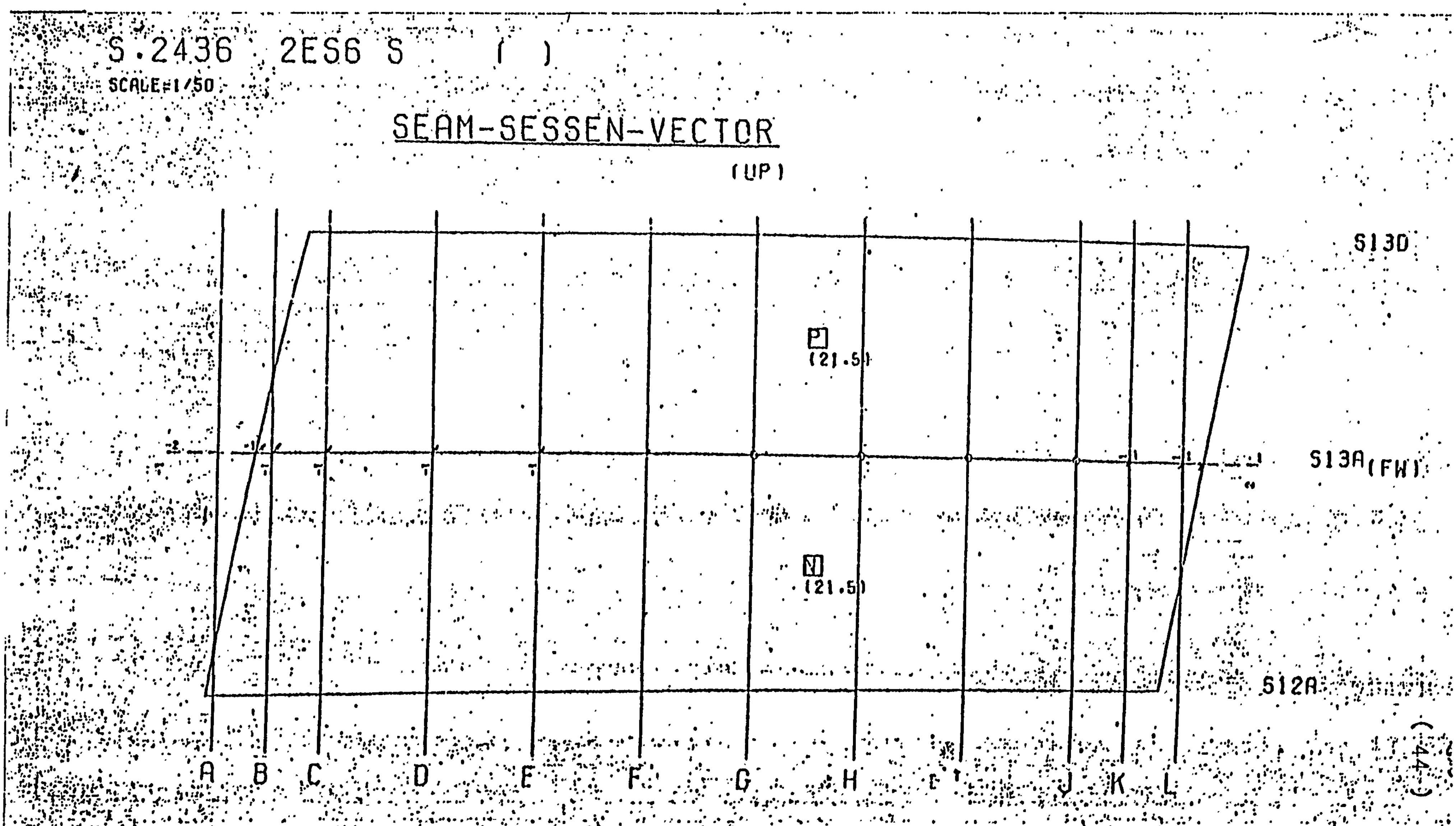
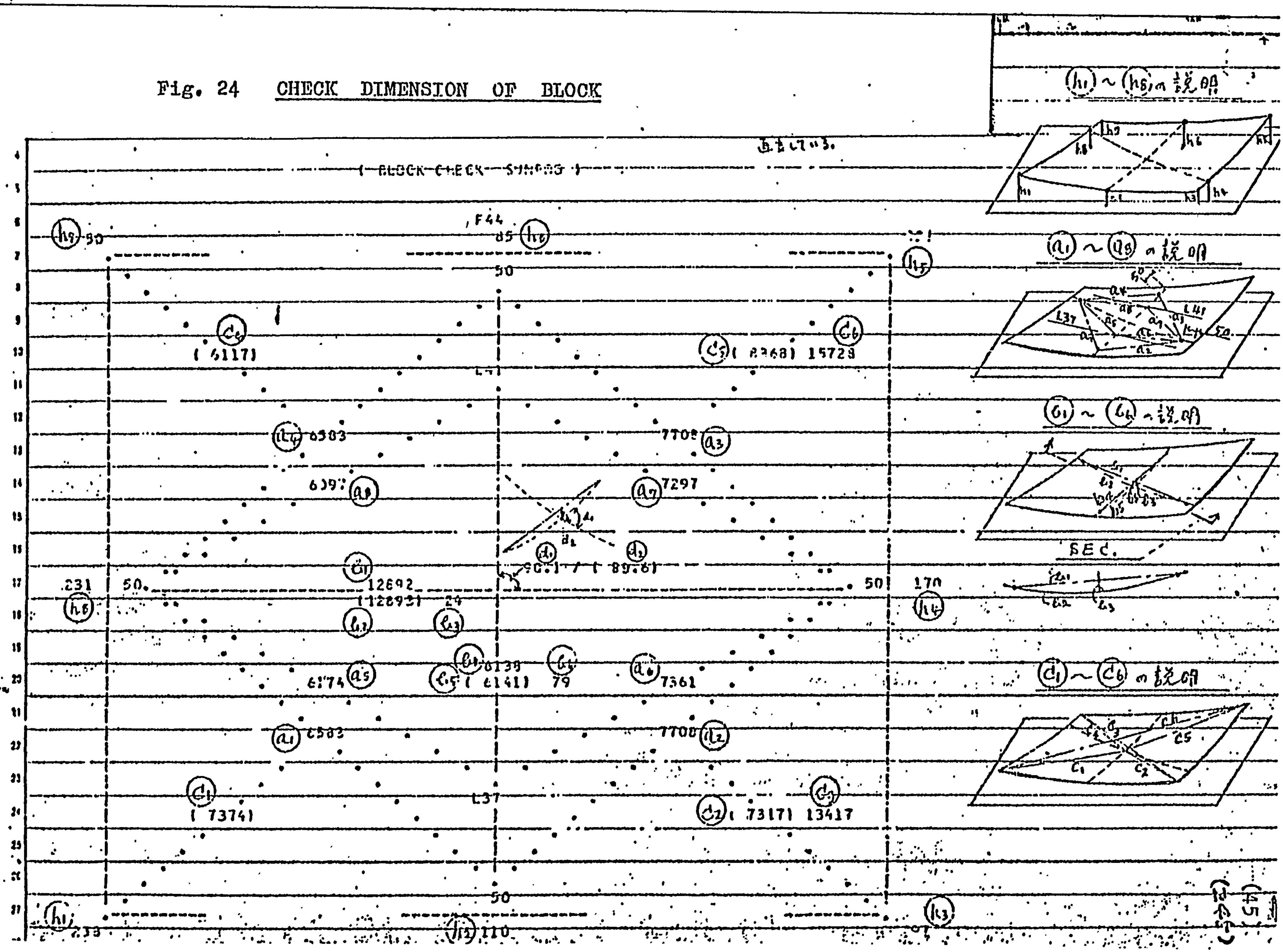


Fig. 24 CHECK DIMENSION OF BLOCK



# APPENDIX D

## LODACS - SHIP FRAME DATA PROCESSING SYSTEM

# Development of LODACS, a Ship Frame Data Processing System

By:
Sumio Kohtake and Hidehiko Matsubara
Ishikawajima-Harima Heavry Industries Co., Ltd.

*Almost all of the previous ship framing computer programs which have been developed and utilized individually at each IHI shipyard not only contained several weak points such as troublesome operation, difficult expression of output showing graphical images by a line printer, and insufficient functions for data processing, but also could not keep pace with the recent progress in the Numerical Control Machines such as steel marking, flame cutting and hydrauric bending equipment. To cope with these circumstances, by standardizing the design and the fabrication procedures and rationalizing graphical output by the dot-printer, X-Y plotter and COM, we have developed a newly integrated system called LODACS (LOngitudinal frame Developing And Conducting System), a system applicable to all shipbuilding facilities and equipment of our shipyards. LODACS, a ship frame data processing system, is now contributing to the improvement of quality and accuracy of framing parts and to the saving of manpower in the design and the fabrication stages. This paper provides an outline of LODACS with actual examples of its outputs.*

## 1. Introduction

Computerization in the field of mold loft work for shipbuilding was initiated in the area of curved shell plate expansion calculation. The storing of the hull offset data into the computer file as an input in such calculations contributed much to the subsequent speedy acceleration of the development of the hull lofting system and promoted the establishment of a comprehensive fundamental system that became an integral part of the hull design system. What is more, the establishment of this hull offset file has had the effect of establishing the method of the longitudinal frame development as the next phase of computerization. Nine years have elapsed since this system was first developed, and seven years have passed since the techniques were universally adopted by our shipyards. The tremendous effects in the areas of work speed-up and labor saving that have resulted from the replacement of the conventional manual lofting system by the computer-aided lofting system can hardly be overstressed.

Following the development of the above method, a twisting mold program for longitudinal members was developed as an associated technique with the primary system, and its extended application to the internal members including end-bracket development was attempted as the component module of the integrated hull design system which, in fact, has been partly implemented. These, however, involved the following problems:

1. There was a lack of mutuality among the programs, due to differences in the time of development, and operational difficulties were observed in the management of the files and program maintenance with their inherent complexities. Such is considered attributable to the difference in their development stages. Further, in the case of the component module of the integrated system, the partial system operation independent from the entire system was not readily obtainable due to the system structural restrictions.
2. The part dimension plans of the longitudinal frames which are the main product of the system were produced in the form of the line printer output, thus the statements had to be expressed only with the code and symbols limited by alpha numeric. As a result, special knowledge was required to read off the statements — one of the causes that lead to erroneous productional operation.

In the meantime, development in the area of NC cutters, NC marking devices and NC frame benders was aggressively advanced in association with the application and implementation of the main system. To keep up with the development in such NC techniques, a basic integrated system has become necessary. The above is the background that lies behind the development of the LODACS (LOngitudinal frame Development And Conducting System). In accordance with the changing demands

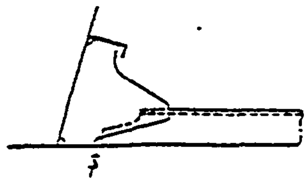


Fig. 1 Example of Frame-end Having Data Common to the End-bracket

at present for ship forms ranging from tankers to cargo boats, efforts are being made to incorporate the transverse frame development program, and practical fields of application of this system have been widened regardless of the limits implied by the original naming of the system.

## 2. Development

In the system development, emphasis was placed on the following points:

1. The system should be capable of processing normal curveless frames, those to be fitted to the shell plates, and also frame-end brackets.
2. The part dimension plans should be output in the form of X-Y plotter, dot printer and COM (Computer Output Microfilm), and be visualized from the dimension tables into dimension plans. No special knowledge or experience is required for reading off the information. English letter or code are used as they provide better access to external users including overseas users.
3. To allow simple operation, each program should be well systematized and unified.
4. The output required for common manual marking should be obtained as basic information, and it should be designed in such a way that the control information can be provided to all the NC devices through the postprocessors.

The features of this system thus developed provide for easy access to the part dimension plan, and outstanding. flexibility allowing applications of the system in any type of shipyard production facilities. Fairly long time was required before determining the suitable specification of a part dimension plan; extensive process standardization was developed by analyzing the marking procedure. A system development should always be based on the end user's requirements; and it is important that the user should not compromise his needs, reasoning that the system producer is limited by restrictions in computer hardware composition or complications in programing. The hull-shop production facilities of our five shipyards are varied in operation systems, ranging from the all NC system to the all manual system; the flexibility of this system has been realized through its application to all the facilities. This system uses the IBM model 370/135 ~ 158 computers at present. The program language employed is principally FORTRAN, and ASSEMBLER is partly used.

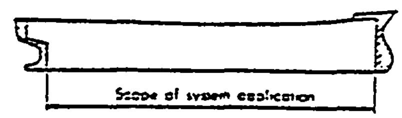


Fig. 2 System Application Range

## 3. Function

This system is designed to deal mainly with the development processing of the hull panel stiffener such as the transverse frames, longitudinal frames and their end-brackets with the added function of a variety of associated application programs. (Hereinafter the transverse frame and longitudinal frame are simply called frames; the frame-end brackets are simply called end-members.) The added capability to handle the end-members was provided mainly because these members are always connected to the frames, and they have elements determining the cutout shapes of frames (Fig. 1). Also, it not only enables the system to simultaneously process the data common to the frames and end-members by a single input operation but also provides ability to process the frame or end-member alone independently.

The scope of application of this system covers the frames and end-members to be fitted to the side shell, upper deck, longitudinal bulk-heads, and various flat decks except for those highly complicated parts at the end of the bow and stern (Fig. 2). As shipbuilding materials, not only the angles and built-up sections, but also slabs and bulb angles are taken into consideration.

## 4. Setting Up

As shown in Fig. 3, the development program is implemented by producing the input data from the hull design, and taking the offset information from the hull base-data file. The results of such a development operation will then be put into the storage of the dimension data file in the case of the frames and standard type end-members, and those off-standard end-members will be stored in the cutter location data file. Subsequent system flow will be processed into the output program groups adaptable to the production facilities being set up in the shipyard under consideration.

### 4.1 Setting Up of System

#### *4.1.1 Development Program*

The development program is the vital part of the system and handles the development processing of the frames and end-members as mentioned above. To simplify the input data as much as possible, the system was elaborated to yield the following functions:

1. According to the kind of section type, dimmension, and bending direction (i.e., outward bending or inward bending), different bending neutral axis is calculated automatically[5].

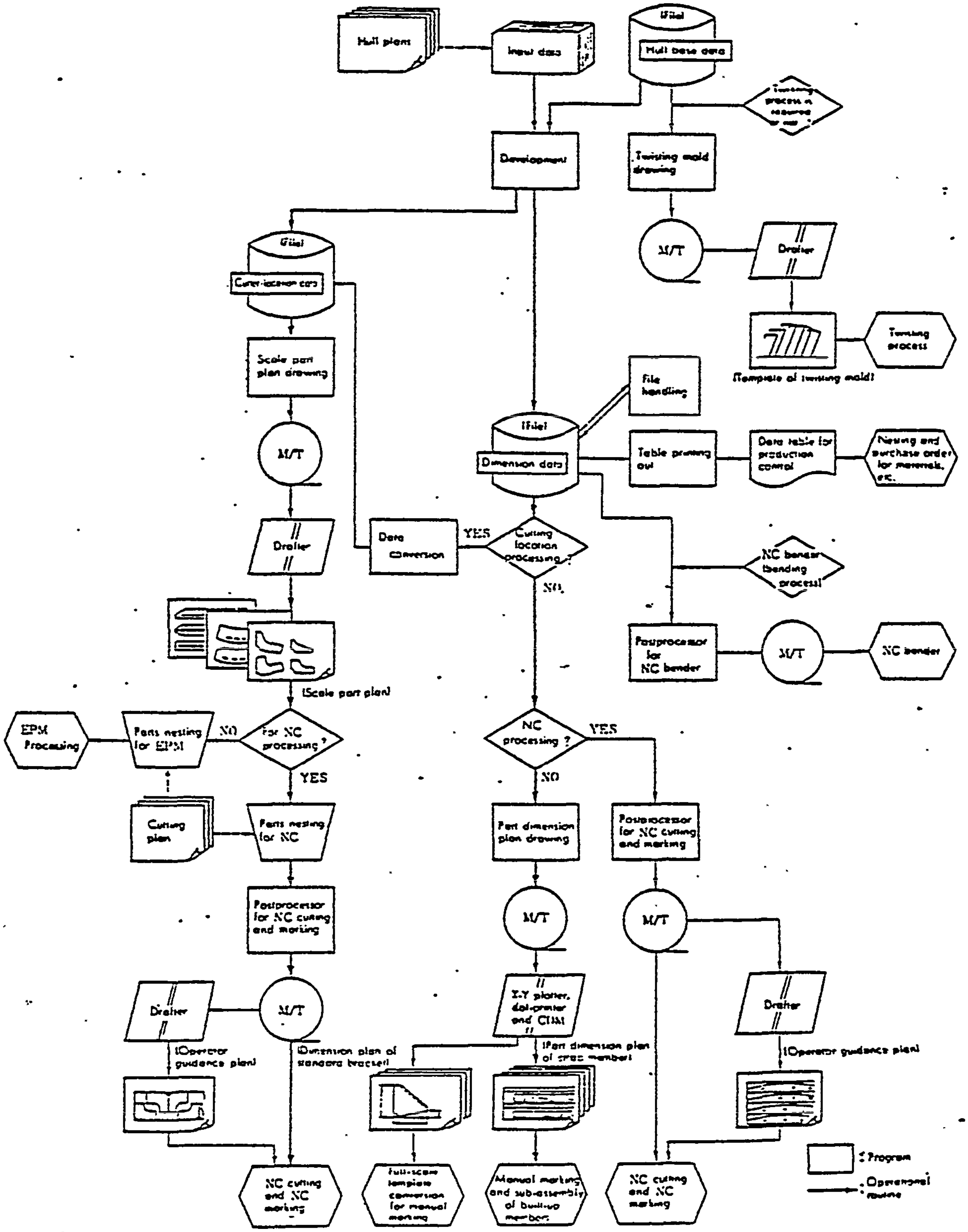



Fig. 3 Flow Diagram

2. Inclined fitting angles of frames, their beveling of edge preparation, and marking surface arc determined automatically.
3. Shapes of frames in detail (cut-off dimension (a), cutout dimension (b). scallop (r) and bevel angles to be profiled ( $\theta$,)$\beta$ etc.) are decided automatically (Fig. 4).

In addition to the above, automatic generation of the data for the secondary members such as face plates and flat bars is mad: possible; the computing function of weight, cutting length, and center of gravity are also provided, and their results are put into the storage of the file. The frame bending lines (Fig. 5) to be made straight after the bending process are computed to a maximum of three lines on judging the scantlings of frames and their bending requirements.

4.1.2 File *Handling program*

The programs that control the dimension data File are:

1. The initializing program that is set when the system operation is initiated.
2. ship to ship data file transfer program to be used partially or entirely for a sister ship or a ship of similar construction and- dimensions.
3. Corrective or cancellative program to be used for partial modification when the design is to be changed in part.

All of the above help to facilitate system operations.

4.1.3 *Production Control Data printing Our program*

To grasp and verify the contents of the dimension data file, and check adequacy of material size for a purchase order and fabrication work scheme this program prints out the parts data such as the block name, code, length, scantling and weight.

*4.1.4 Part Dimension* Plan *Drawing Program*

A part dimension plan is drawn by the X-Y plotter (Fig. 6), dot printer (Fig. 7), or by COM with the required output from the dimension data file for the manual marking and built-up guidance plans. In this process, data are not only assorted according to groups of classified materials such as slabs, angles and built-ups or bend pieces and straight pieces but also assorted based on the fabrication lines, scantlings and the order -of lengths to suit the intended purposes.

All the shapes are unified in figures and/or terms of actual *images* and the title code and the like are stated in English in consideration of possible license agreement with shipyards in foreign nations (Fig. 8 - *Fig. 11).*

*Namely:*

| | |
|---|---|
| PART CODE | Code of parts |
| - SCATLING | Sectional dimensions -- |
| SHOWN | Surface shown on the plan |
| s . PRM | Preliminary surface treatment & Shop prima painting |

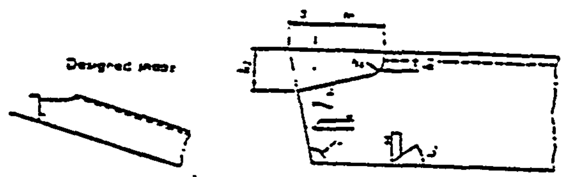



Fig. 4 Example of Fram-end Decided Decided Automatically

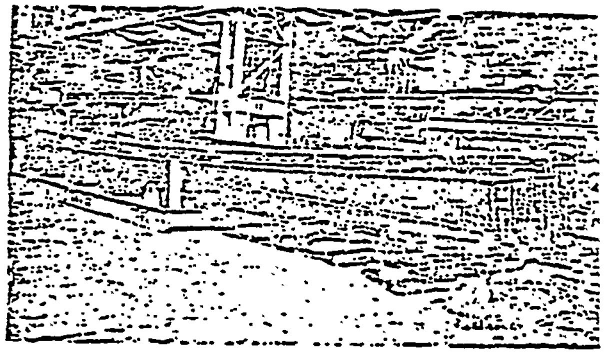


Fig. 5 Frame Bending Line Straightened after Bending.

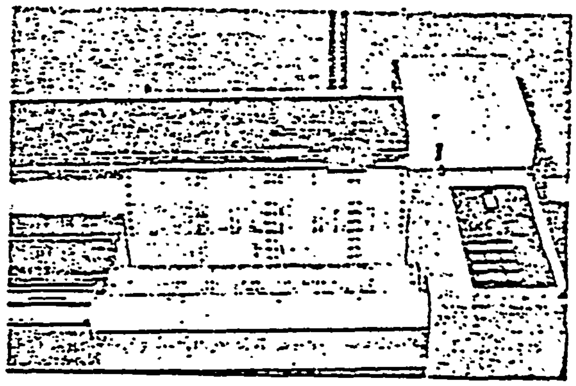


Fig. 6 Drawing View of Pan Dimension Plan by the X-Y Plotter

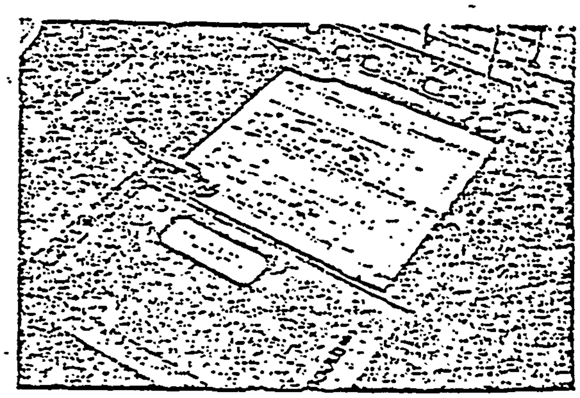


Fig. 7 Drawing View of Part Dimension Plan, by the Dot Printer

BEND Bending method

TWIST Twisting in fabrication shop

[T]hese represent only a few examples. To facilitate [man]ual marking, due considerations were taken on the [foll]owing points:

1. Marking length is shown on the & basis of the cumulative dimensions, and in particular the end Cut out sequence is made identical to those in manual marking procedure.

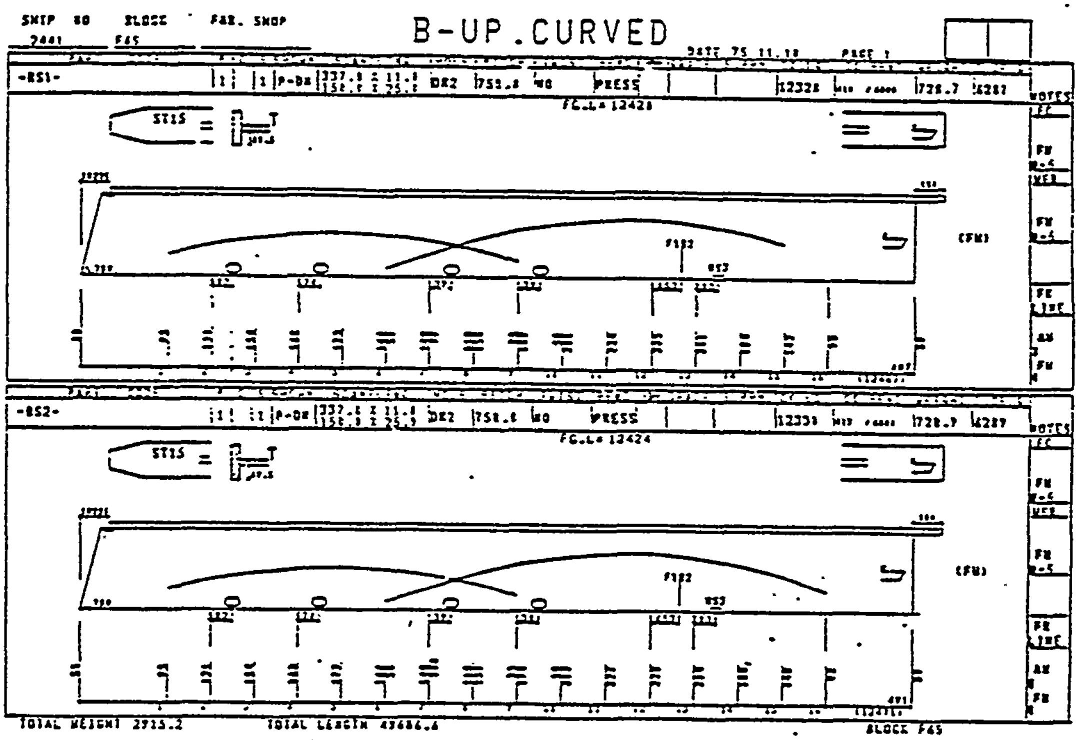



Fig. 8 Part Dimension Plan of Curved Built-up Frame (by COM)

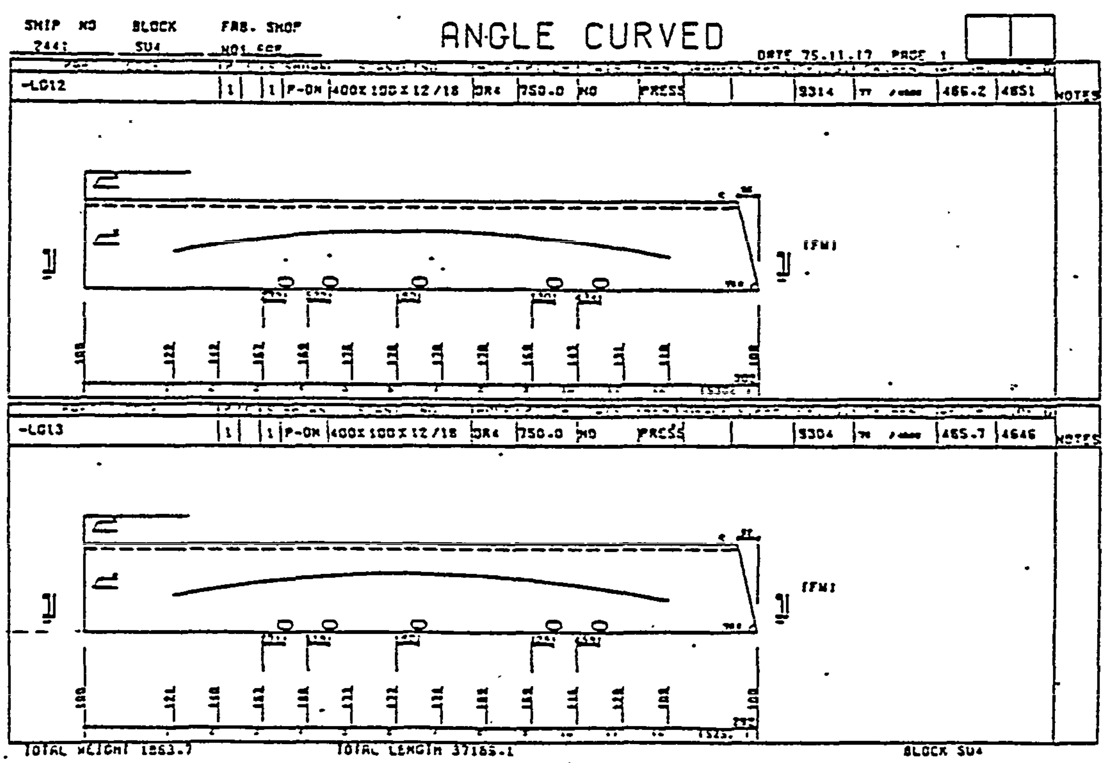



Fig. 9 Part Dimension Plan of Curved Angle Frame (by Plotter)

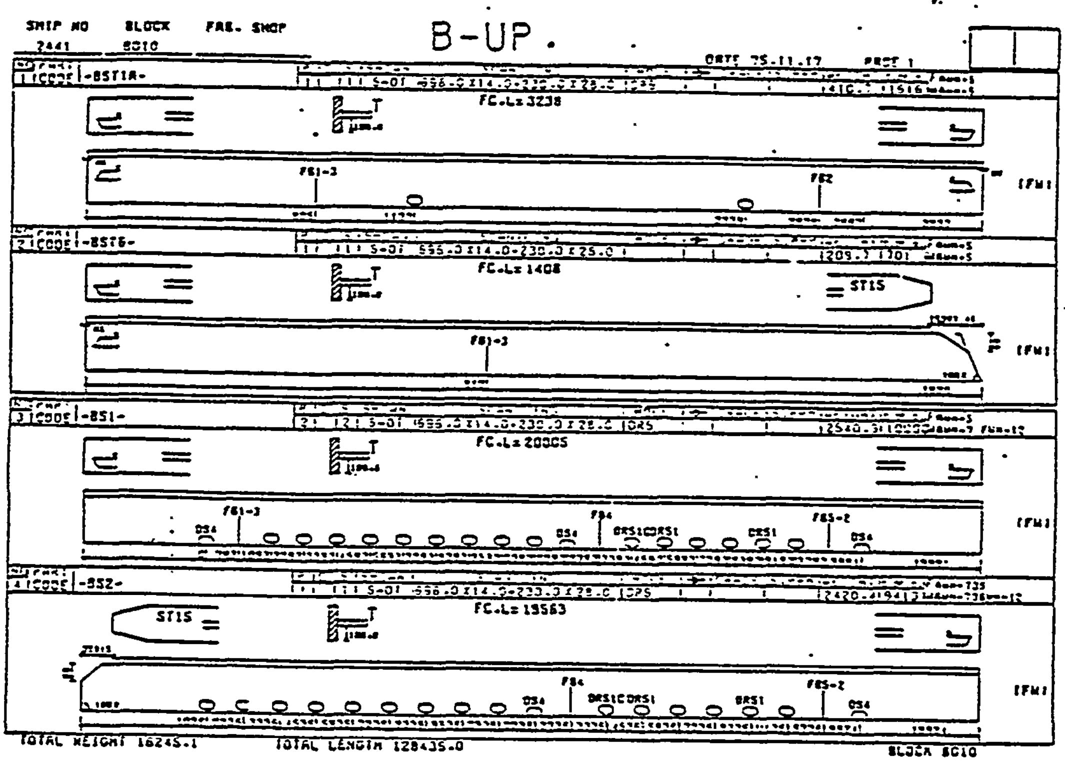


Fig. 10 Part Dimension Plan of Straight Built-up Frame (by Plotter)

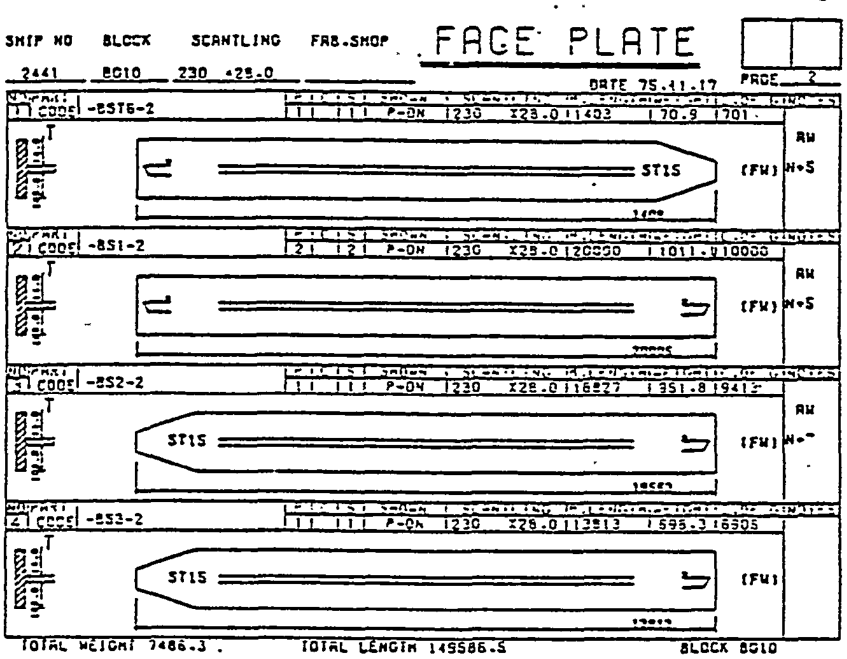


Fig. 11 Part Dimension Plan of Face Plate of Built-up Frame (by Plotter)

2. Drawing is made with the same side view as marking is.
3. End shapes and bending line curves are expressed in a somewhat exaggemted manner to improve presentation of images.

The part dimension plan (Fig. 12) of the curve cutout frame differs from that in the ordinary bending process effected by referring to the frame bending the in that an analogous pattern requiring no bending process can be restored by marking through the dimensional con from one base line. In the case of the standard brackers the program also provides the dimension output aSSum possible requirements for the marking with a given of dimensions or full-scale template conversion.

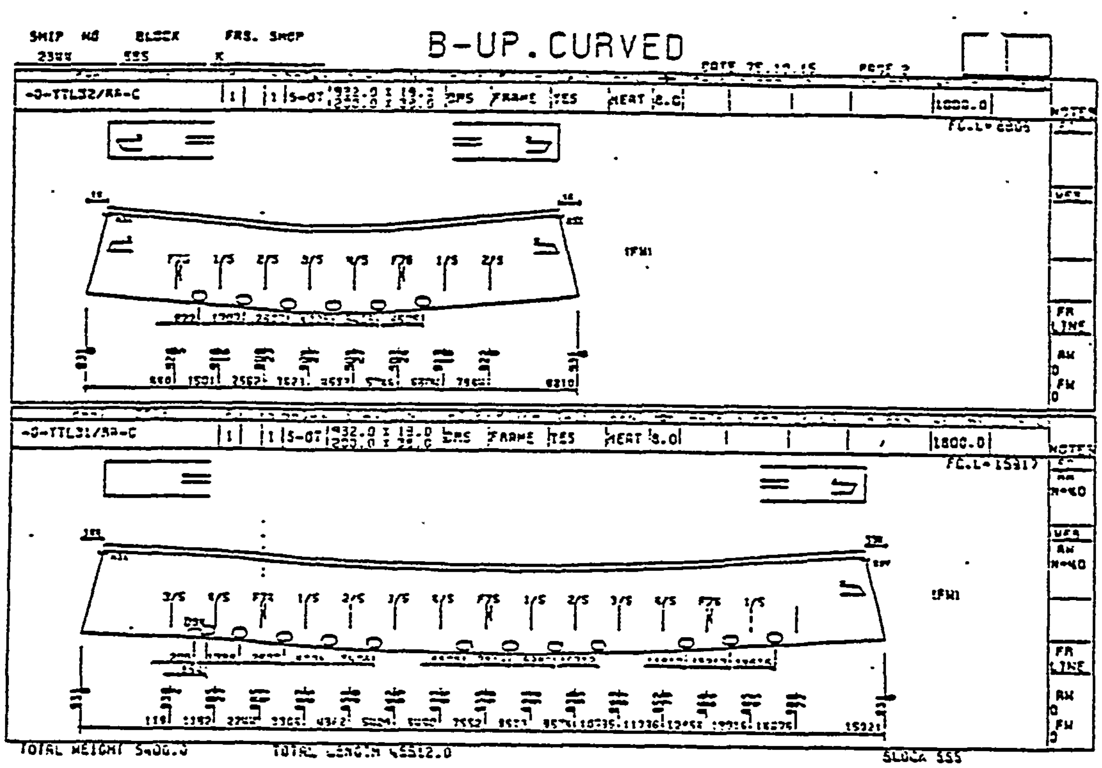



Fig. 12 Parr Dimension Plan of Cut-out Frame [by Dot-printer]

#### *4.1.5 Posiprocessor for Numercally Controlled Frame curring and Marking*

This program outputs NC tape, by which the cutting of drain holes on the frame and frame-ends, the marking of the frame bending line and other necessary lines are conducted by the NC frame cutter (Fig. 13). It also carries out parts nesting automatically with the given information from the dimension data file as required; output in the form of magnetic tape or punched tape is provided. This punched tape will then be fed into the drafter capable of checking the contents of the information to draw a plan in a *1/20* scale which will further be supplied to an operator of the NC cutter as a guidance plan (Fig. 14).

#### 4.1.6 ***Posrprocessor*** for ***Frame NC Bender***

This is a postprocessing program that acts *to* subject the cut frames to the automatic bending process by the *NC* frame bender (Fig. 15). The data necessary for frame bending is obtained from the dimension data file to determine the distance between the points of press action in accordance with the bending requirements, and the computed magnitude of bending action will be output to magnetic tape as the control numerical data in terms of angular quantity.

#### 4.1.7 Production Program of Twisting Mord

When twisting of the frame is judged necessary by the design criteria, the essential data arc obtained from the hull base data file in accordance with the name of longitudinals, and designations specifying the range. In the case of manual 0peration, necessary information should be obtained from the ship's body plan. Thus the twisting mold is made so as to be set on the transverse

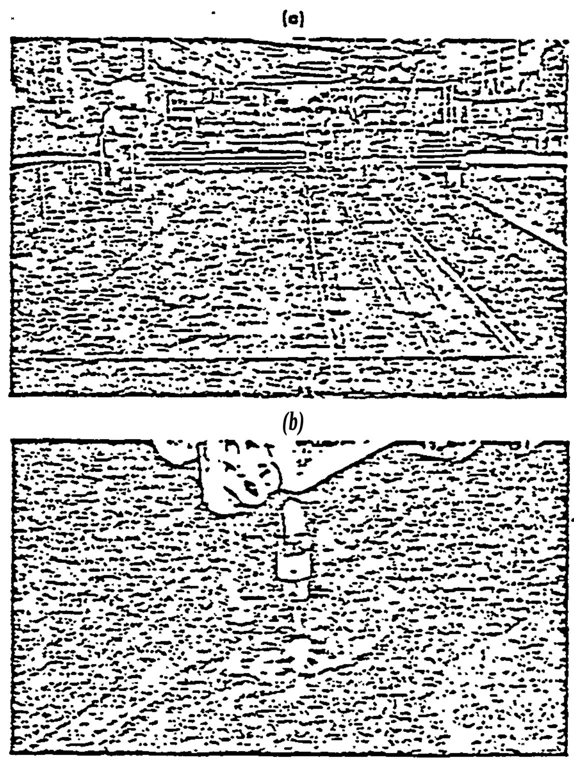



Fig. 13 Frame Fabrication by the NC Frame Cutter

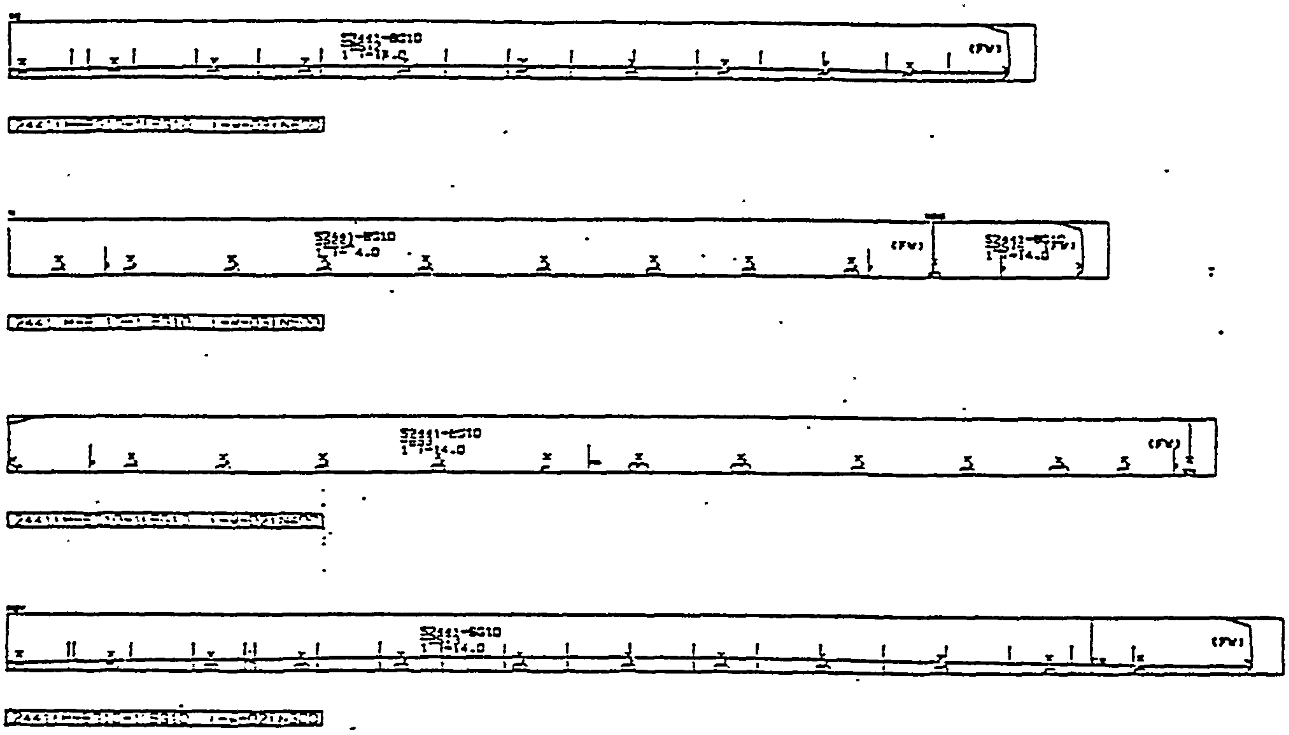


Fig. 14 Operator Guidance Plan for Frame NC Cutting

frame lines; further, it involves a certain degree of angle to the web surface of the longitudinal. This program provides the output of twisting mold at a right angle to the shell line and web surface. With the processing of this program, not only can the marking of transverse frame lines be omitted but also the twisting operation itself has improved significantly (Fig. 16).

*4.1.8 Data Conversion Program*

When the standard brackets, cutout frames and face plates being stored in the dimension data file are to be drawn as output in the form of EPM film or full-scale contour templates, the dimensional data can be expressed as cutter location data which are stored in the cutter location data file.

*4.1.9 1/10 Scale Part Plan Drawing Program.*

This program outputs magnetic tape for drawing by designating the block name or the part code from the cutter location data file. This magnetic tape will then be used to draw a 1/10 scale part plan film (Fig. 17) by the drafter. This part plan is used for multiple purposes such as EPM, film for projector marking, and parts nesting for NC marking or NC cutting.

*4.1.10 Postprocessor for NC Cutting*

The parts nesting produced by the above part plans will be channelled through this postprocessor to output data in the form of magnetic tape or punched tape per every unit of steel plates. As with the case in the postprocessor (*4.1.5*) for frame NC cutting and marking,

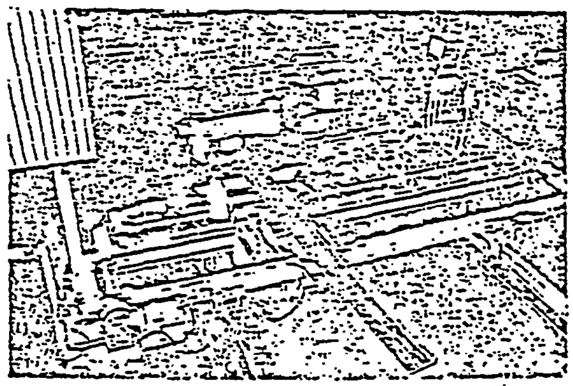


Fig. 15 Frame Bending by the NC Bender

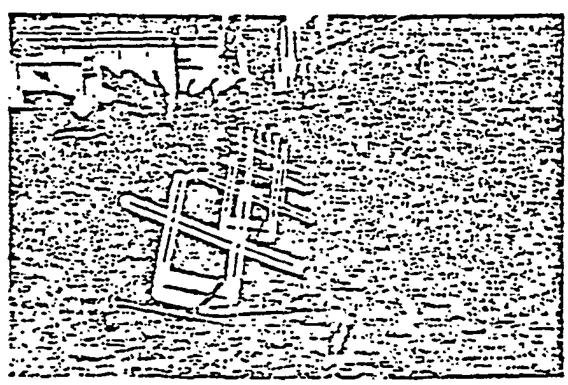


Fig. 16 Frame Twisting

such tape will be supplied to the work site together with the operator guidance plan drawn by the drafter. In other words, this program can follow up either the NC cutter or NC marking device (Fig. 18).

4.2 Setting Up of File

### *4.2.1 Hull Base Data File*

The Direct Access Method type file is used wherein the hull offsets, scantlings of the longitudinals, those section types, and specific data of the longitudinals such as the thickness side of webs against mold line and the direction of the flanges are contained. Furthermore, this file is not only utilized for the LODACS but also for the shell plates expansion and internal members development processes.

### *4.2.2 Dimension Data File*

This Direct Access Method type dimension data file containes the indices of block names. Here, the developed frames. face plates and flat bars known as the strap members, and standard type brackets and cutout frames are included in the dimensional forms. Each component member has its corresponding record, and the information consists of the general items such as the part cod:, santling. length and control parameter for production activity, the common graphical items such as end shape and scallops, bending information. data regarding drain holes, and marking information.

### *4.2.3 Cutter Location Data File.*

This Direct Access Method type curter location data file contains the cutter location data which arc to be output in the form of the analog patterns. In addition to the end-members, the standard type brackets, face plates and cutout frames data converted from the above dimension data file can be put into the storage of this file- as required. This file, as with the cases above, can be utilized also for other systems covering the expansion

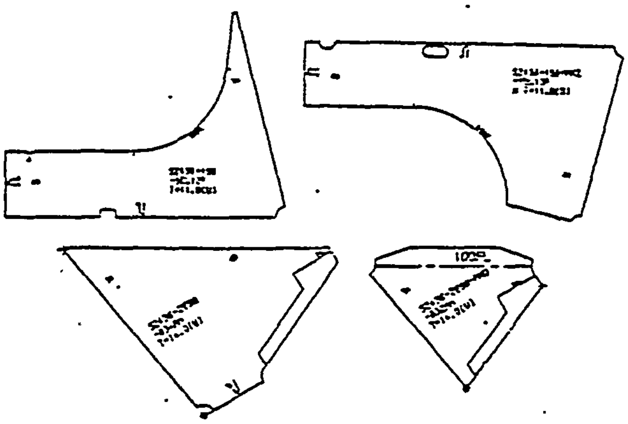


Fig. 17 Part Plan of Frame End-bracket (by Drafter)

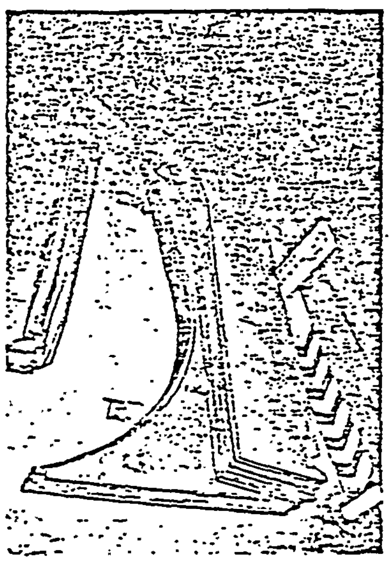


Fig. 18 Frame End-bracket by NC Cutting

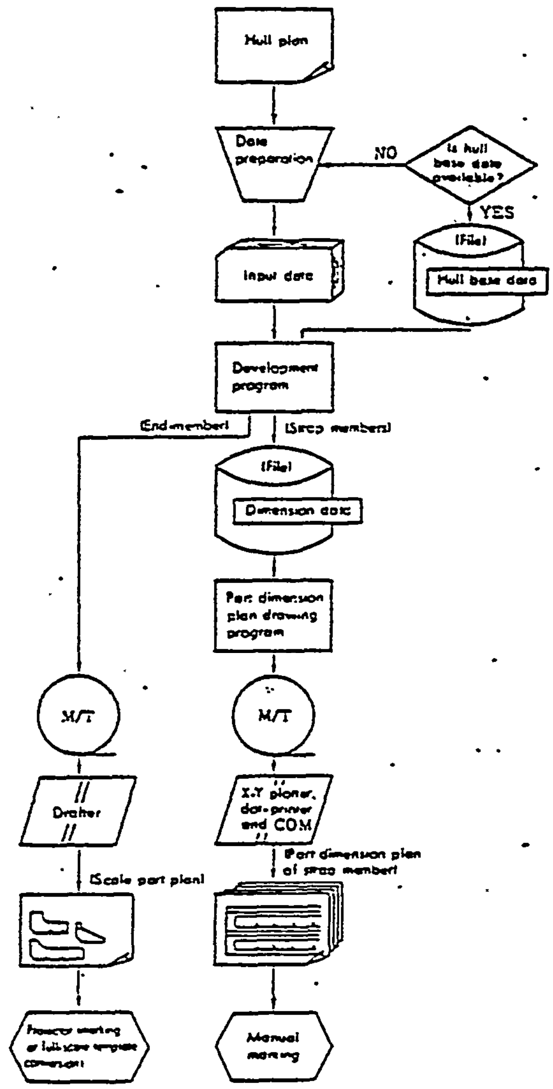



Fig. 19 Example of System Operation Flow Chart

curved shell plates and development of internal members.

## 5. Operation

### 5.1 Preparation for System Operation and Its Simplified Operation

With respect to the flow diagram shown in Fig. 3, a variety of operational methods an be taken Namely, only those necessary programs can be selected after development programs.

The preparation of the dimension data file is indispensable for the control of the files, but in an emergency as: as in the quick repairs of a vessel, specific data can be input even when the hull base data file is not available. When the preparation of EPM films or full-scale templates is intended, the cutter location data file may be bypassed, and magnetic tape tape or punched tape for NC drafting can be output directly from the development program. Shown in Fig. 19 is an example Of the system operation without utilizing the hardware techniques of numerical control fabrication.

### 5.2 Standardization

It goes without saying that computerization and standardization go hand in hand. Extensive standardization which resulted in distinct simplification both in design and in input operation was developed in this system. In particular, five types of frame-end shapes and more than ten types of end-members have been standardized Consequently, the necessity to write down all the details of end-members in the design phase has been eliminated. All that is required is to note the designated type number of end-member shown in the standard specifications. Similarly, only the designated type number of end-member shown on the relevant design plan is required to be input. The newly provided access permitting the input of those principal dimensions related to design functions allows added system flexibility to deal with the hull members of special types, and contributes significantly to even greater labor saving.

### 5..3 Input

Input items of the system, aside from the development program, con&m the block names, part codes and selective machine code, hence description on these items is omitted her:. In this article the input for the development program will be shown. Generally. processing is made for every building block where data are broadly classified as those data common to blocks and those concerning each frame member.

#### *5.3.1 Data Common 10 Blocks*

These data cover the ship number, block name, and drain holes which require only one input operation at the initial stage of each block processing. Of these, the input operation for drain holes is cumbersome; however, simplification has been made in such a way that the type of drain holes can be omitted where they are identical to those on the immediately preceding member.

#### 5.3.2 Data Specific to Each frame

To minimize the input operation frequency, the name of the longitudinal. type number of the end-member, range of frames processed and specific data other than the standard type are required to be input for the first member only, but all such data for the subsequent members can be largely omitted, except for the name of the longitudinal and part cod: name. providing that they are dimensionally identical to the first one.

## 6. Conclusion

With comprehensive coverage and sophisticated functions, LODACS has. become an extremely useful system that meets the multiple requirements of the shipbuildiig design and production system. As already mentioned, this system it a longitudinal frame development and conducting system incorporating the groups of programs developed and implemented by MI with added functions later developed. This system does, however, have some unsolved problems in dealing with the transverse frame end-brackets, beams and beam-knees etc. Other problem areas include such items as the automatic drawing of the sectional view of frames in the course of hull plan preparation, supplying those control data *to* the production control system, and the like, to name but a few. A greater corporate effort will thesefore be made in the future to solve these remaining problems.

## References


(1) Numerical Control Committee, The Society of Naval Architects of Japan: Numerical Control Techniques in Shipbuilding. The Society of Naval Architects of Japan, 1972

(2) S. Kohtake: Current Status of Integrated System in IHI Ships Hull structure Design, The Society of Naval Architects of Japan No. 560 Feb. 1976 pp. 22-31

(3) Y. Horiba and T. Morokoshi Ship Design System Aided by Graphic Display Equipment. IHl Engineering Review, Vol. 7 No. 1 Jan 1974 pp. 33-43

(4) S. Kohtake, H. Hamajima and K. Shimizu IHI High Speed NC Marking System, Ishikawajima-Harima Engineering Review Vol. 16 No. 1 Jan. 1976 pp. 100-106

(5) I. Tsuji: On the Position of Neutral Axis of Section during Bending. Transactions West-Japan Society of Naval Architects No. 27 My. 1964 pp. 147-460

# APPENDIX E

## SPECS - SHIP'S PRELIMINARY AND EXACT CALCULATION SYSTEM

SYS.ENG.GRP.

# SPECS

SHIP'S PRELIMINARY AND EXACT CALCULATION SYSTEM

IHI
ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES

OCT. 1978

Ishikawajima-Harima
Heavy Industries co, Ltd.
TOKYO JAPAN

REF. No.

HL-781002

## (1) ABSTRACT OF 'SPECS' SYSTEM

This system shall be applied to detailed design in ship's preliminary calculation on Hull Form and its capacities. The system design concepts and aims are as below.

* Expansion of application by widely used programs
* Easy Maintenance of both programs and Data.
* Reconsideration of design system and Pursuit of man power saving.

This is a totalized system which can make designers possible to prevent from duplicate input by registration the results of each step in the Data Bank through which next programs shall retrieve them.

## (2) APPLICATION AND RESTRICTIONS

### 1) Applied ship's type

Applied tankers and carriers up to D/W 1,000,000

In addition to the ordinary ships, following type can be also applied.

Ship's type --------- naval vessels, patrol ships, fishing boats

Hull form ----------- Initial trim, Knuckled shell

Inner hull structure ------- Almost all types of ship shall be applied using MAP-method developed by IHI.

4

### 2) Other restrictions

ORDINATE ------------ Max, 50 (W.L = 60)

FRAME --------------- Max, 500 (W.L = 150)

TANK / HOLD ---------- Max, 70 block

Loading condition --- Max, 100

## (3). FEATURE OF THE SYSTEM

1. Operating methods

   * Using as total system which can save input data by retrieval the preceding results from the data Bank.

   * Independent RUN method
   Related data to be INPUT directly for each program.

   Both running method are available.

2. Drawing shall be generated as output.

3. Calculated results in the Bank can be applied to another sister ship for effective process.

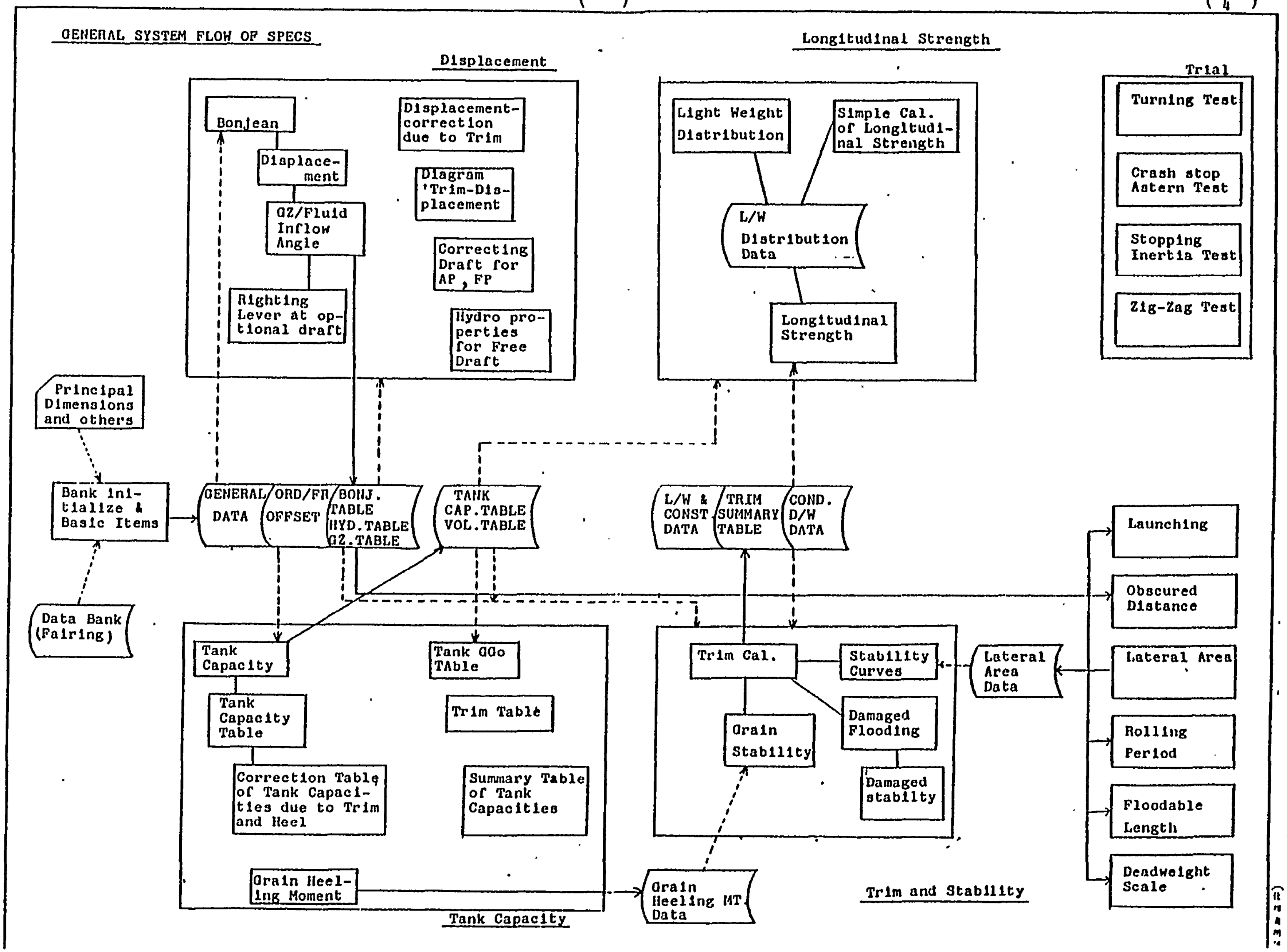
4. FRAME & ORDINATE OFFSETS shall be automatically applied, in case that LINES FAIRING has been complexed.

4

5. FRAME OFFSETS can be provided from ORDINATE OFFSETS' by OPTION FUNCTION.
   Various studies in initial design stage can be proceded by this function.

6. MAP- method developed by IHI shall make it easy to apply the system for the complexed shapes of ship.

7. New Rules of IMCO are applied.


GENERAL SYSTEM FLOW OF SPECS
Displacement
Bonjean
Displacement
GZ/Fluid Inflow Angle
Righting Lever at optional draft
Displacement-correction due to Trim
Diagram 'Trim-Displacement
Correcting Draft for AP, FP
Hydro properties for Free Draft
Longitudinal Strength
Light Weight Distribution
Simple Cal. of Longitudinal Strength
L/W Distribution Data
Longitudinal Strength
Trial
Turning Test
Crash stop Astern Test
Stopping Inertia Test
Zig-Zag Test
Principal Dimensions and others
Bank initialize & Basic Items
Data Bank (Fairing)
GENERAL DATA
ORD/FR OFFSET
BONJ. TABLE HYD.TABLE GZ.TABLE
TANK CAP.TABLE VOL.TABLE
L/W & CONST DATA
TRIM SUMMARY TABLE
COND. D/W DATA
Launching
Obscured Distance
Lateral Area
Rolling Period
Floodable Length
Deadweight Scale
Tank Capacity
Tank Capacity Table
Correction Table of Tank Capacities due to Trim and Heel
Tank GGo TAble
Trim Table
Summary Table of Tank Capacities
Grain Heeling Moment
Tank Capacity
Trim Cal.
Stability Curves
Damaged Flooding
Grain Stability
Damaged stabilty
Lateral Area Data
Grain Heeling MT Data
Trim and Stability

## (4) FUNCTION AND OUTPUT OF EACH PROGRAM

| Program name | Function of Program | Output |
|---|---|---|
| BANK INITIALIZE & Basic items | Preparation for I/O process of all calculations shall be done. Basic items such as principal dimensions,FRAME SPACE and etc. are stored. | |
| Bonjean Cal. | Bonjean calculation of MLD and EXT are executed. | Bonjean (EXT)<br>Bonjean (MLD)<br>Bonjean Curves |
| Hydrostatic Properties Cal. | HYDRO PROTERTIES TABLE is generated. | MAP APPEN |
| GZ and FLUID INFLOW ANGLE Cal. | Calculation of GZ (Righting Lever) at any angle.<br>Calculation of the displacement at the start of INFLOW of sea water. | Cross Curve of stability<br>Curve of INFLOW angle |
| Righting Lever at optional draft | GZ TABLE at optional draft is generated. | GZ for operational information<br>GZ-Healing Curves |
| Displacement-correction Cal. due to Trim | Displacement correction Table in optional draft-Trim is generated. | Displacement correction table due to Trim |
| 'Trim-Displacement' Diagram | Generating Diagram 'Trim-displacement' for finding draft at bow and stern. | Diagram 'Trim-Displacement' |
| Draft Correction Table at the point of draft Mark | Values for correction which shall be used for calculating drafts at the both of AP and FP from the appearent drafts at the Draft-Mark position. | Draft correction table for Draft-Mark |
| HYDRO Properties Cal. for Free Draft | Calculation of HYDROSTATIC PROPERTIES at any part of the ship, at Trim-status and at HOG & SAG status. | HYDRO PROPERTIES for Free Draft |
| Read in frame offsets | Frame offsets read by eyes. | Frame distance table<br>Frame offsets |

| Program name | Function of Program | Output |
|---|---|---|
| Tank Capacity Cal. | Capacity, center of Gravity INERTIA etc. are calculated. | Tank capacity table<br>Tank capacity curves |
| Tank Capacity Table Cal. | Tank capacity table is generated due to SOUNDING and ULLAGE. | Tank capacity table |
| Correction Table of Tank capacities due to Trim and Heel | Value for correction against EVEN KEEL at TRIM HEEL is calculated. | Correction value table |
| Grain Heeling Moment Cal. | TRANSVERSE & VERTICAL HEELING Moment are calculated. | Grain Heeling Moment table |
| GGO Table for Operational Information | Decrease of GM by free surface effect is calculated. | Table |
| TRIM Table | Estimation of the change of Trim when a load of 100t added to optional Tank. | Trim Table |
| Summary of capacities of Tanks and etc. | Final drawing of Tank Capcity. | Tank Capacity Summary Table |
| Trim Cal. | HOMOGENEOUS LOADING at optional Tank and Trim adjustment by two fixed tank. | Loading condition Drawing |
| Lateral area Cal. | Lateral area and center of Lateral area are calculated. | Curve of Lateral Area |
| Stability Curves Cal. | GZ angle of vanishing stability and GZ maximum. Coefficient $C_1$ , $C_2$ considered DYNAMICAL STABILITY of IMCO Rule, maximum allowable helling angle, wind and oscillation. | Diagram 'GZ-Heeling angle-Dynamical stability' |
| Grain Stability Cal. | Residual Area, Heeling angle, Allowable Heeling Moment etc. are calculated. | Table of Heeling Moment Diagram 'GZ-Heeling Angle' |

4

| Program name | Function of Program | output |
| --- | --- | --- |
| Damaged flooding and damaged stability Cal. | Final balanced CONDITION after damaged by method of lost Buoyancy is generated. DYNAMICAL STABILITY considered wind and oscillation can be also calculated. | Diagram GZ-Heeling Angle |
| Light Weight distribution Cal. | Light Weight, center of Gravity are calculated and distributed. | Light Weight Distribution Curve |
| Longitudinal strength Cal. | SF. BM DEFLECTION in case of STILL, SAG, HOG are calculated. | Comparison Table for Bending Moment<br>Diagram Bending Moment-Shearing Force<br>Envelope Curve of Shearing Force<br>Envelope of Bending Moment |
| Simple Cal. of Longitudinal Strength | BASE VALUE such as Coefficient of Weight Distribution Shearing Force etc. at the point of Bending Moment are calculated. | Coefficient of Weight Distribution for Shearing Force<br>Lever for Bending Moment<br>Longitudinal strengthen Data |
| Launching Cal. | Launching particulars, Float condition, launching speed etc. are calculated. | Launching Curves<br>Launching Speed and Travel Curves |
| Obscured distance in relation to various Draft and Trim | Table of Obscured Distant at the designated draft and Trim is generated. | Table of Obscured Distance in relation to various Draft and Trim |
| Rolling period Cal. | Table of GoM at every designated draft and oscillation period is generated. BY Kato's equation or results of experiment. | Bolling Period-MM Table |

4

| Program name | Function of *Program* | Output |
|---|---|---|
| Floodable length Cal. | Floodable and Permissible length at optional points are calculated. By the standard of Ministry of Transport or Floodable length detailed Bonjean Method. | Floodable Length Curve |
| Dead Weight-Scale Drawing | D/W SCALE unit in METRIC or FEET. | Dead weight-Scale |
| Turning Test | Measured results such as Speed and Turning Angle at the Trial are analyzed and calculated. | Drawing on Turning Test |
| Crash Stop Astern Test and stopping Inertia Test | Results of Crash Stop Astern Test and stopping inertia test are analyzed. Its wake and speed curve are drawn. | Results of crash stop Astern test<br>Cource of Crash stop Astern Test<br>Result of Stop-ping Inertia Test<br>Course of Stop-, ing Inertia Test |
| Zig-Zag Test | Results of Zig-Zag steering Test are analyzed. | Table of Maneu-vability |

4

# APPENDIX F

## SPECS - ACTUAL OUTPUT EXAMPLE

| REPORT NO |
|---|
| Y-5 - |

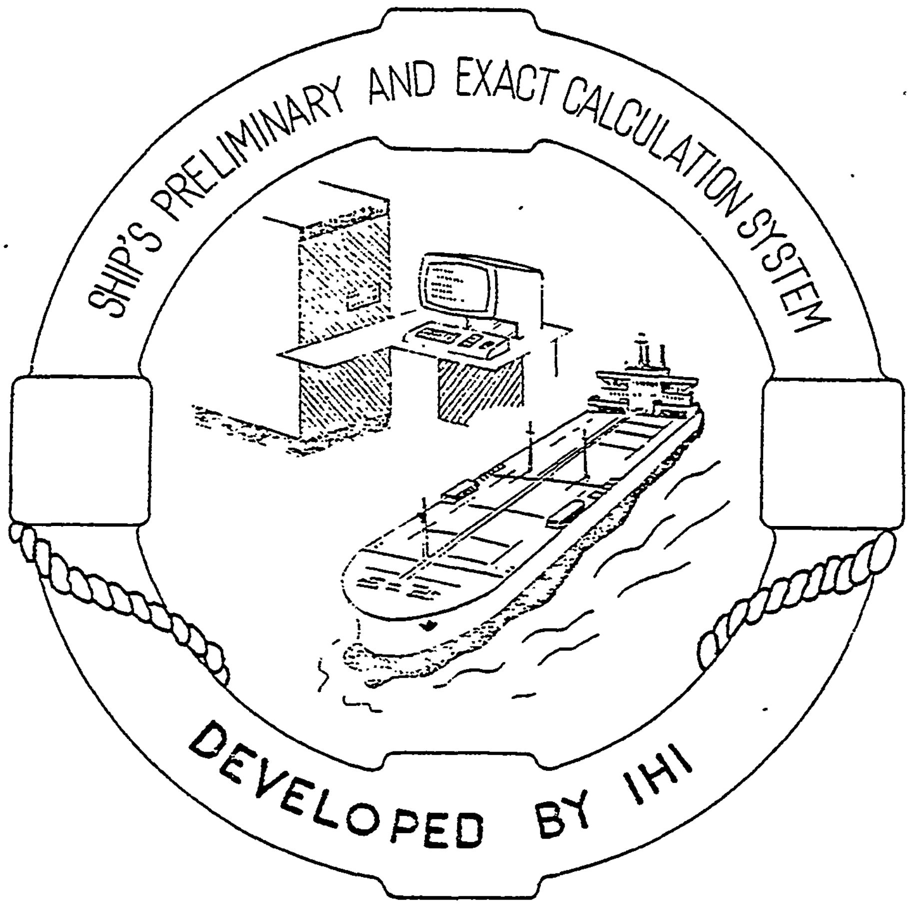
# SPECS

ACTUAL OUTPUT EXAMPLE

OF

SHIP'S PRELIMINARY AND EXACT

CALCULATION SYSTEM




IHI 石川島播磨重工業株式会社

## *INDEX*

*** PRINCIPAL PARTICULARS ***

| | |
|---|---|
| LENGTH OVER ALL | 187.730 M |
| LENGTH BETWEEN PERPENDICULARS | 178.000 M |
| BREADTH (MOULDED) | 20.400 M |
| DEPTH (MOULDED) | 15.300 M |
| DRAFT (DESIGNED MOULDED) | 9.750 M |
| DRAFT (DESIGNED EXTREME) | 9.768 M |
| INITIAL TRIM | 0.0 M |
| DISTANCE AFT.END FROM A.P. | 5.000 M |
| DISTANCE FWD.END FROM F.P. | 4.730 M |
| RISE OF FLOOR AT MIDSHIP | 0.0 M |
| STARTING POINT OF RISE OF FLOOR | 1.095 M |
| RADIUS OF BILGE CIRCLE | 1.200 M |

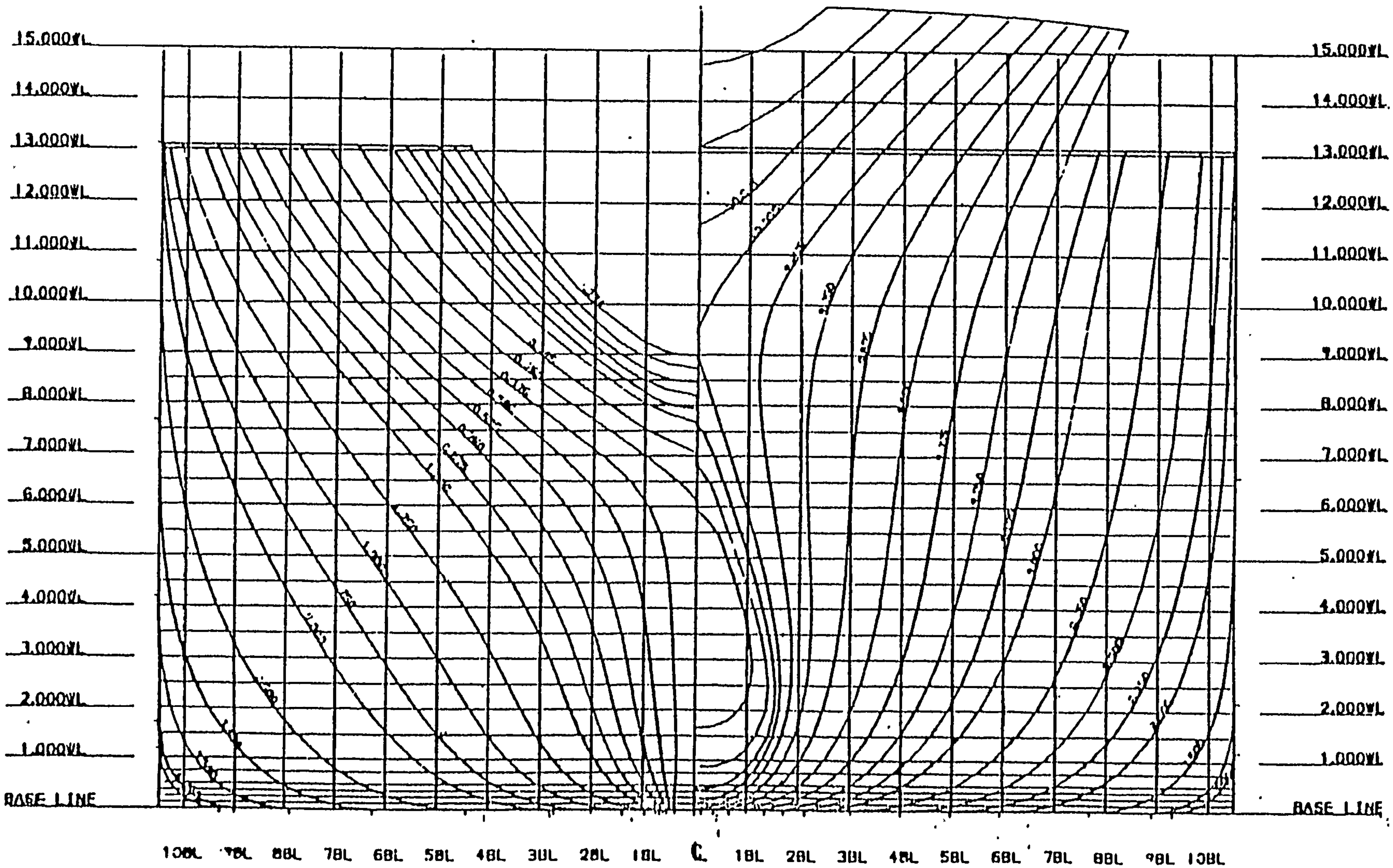
```
**************************
*                        *
* SEA GRAVITY = 1.02500  *
*                        *
**************************
```

## ORDINATE OFFSET ( 0.050 M W.L. - 5.000 M W.L.)



| ORDINATE NO. | 0.050 M W.L. | 0.125 M W.L. | 0.250 M W.L. | 0.375 M W.L. | 0.500 M W.L. | 0.750 M W.L. | 1.000 M W.L. | 1.500 M W.L. | 2.000 M W.L. | 3.000 M W.L. | 4.000 M W.L. | 5.000 M W.L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.2878 | | | | | | | | | | | | |
| -0.2388 | | | | | | | | | | | | |
| -0.2714 | | | | | | | | | | | | |
| -0.2079 | | | | | | | | | | | | |
| -0.1443 | | | | | | | | | | | | |
| -0.0722 | | | | | | | | | | | | |
| 0.0 | | | | | | | | | | | | |
| 0.1250 | | | | | | | | | | | | |
| 0.2500 | 0.400 | 0.400 | 0.400 | 0.400 | 0.245 | 0.175 | 0.135 | 0.100 | 0.090 | 0.090 | 0.090 | 0.090 |
| 0.3750 | 0.465 | 0.483 | 0.506 | 0.531 | 0.556 | 0.607 | 0.653 | 0.736 | 0.800 | 0.891 | 0.970 | 1.066 |
| 0.5000 | 0.576 | 0.634 | 0.731 | 0.819 | 0.905 | 1.055 | 1.185 | 1.378 | 1.514 | 1.707 | 1.863 | 2.070 |
| 0.6250 | 0.785 | 0.917 | 1.098 | 1.247 | 1.377 | 1.598 | 1.783 | 2.057 | 2.250 | 2.537 | 2.782 | 3.088 |
| 0.7500 | 1.119 | 1.317 | 1.572 | 1.768 | 1.931 | 2.204 | 2.429 | 2.771 | 3.022 | 3.394 | 3.725 | 4.127 |
| 0.8750 | 1.533 | 1.785 | 2.088 | 2.321 | 2.516 | 2.838 | 3.096 | 3.497 | 3.798 | 4.261 | 4.682 | 5.168 |
| 1.0000 | 1.965 | 2.282 | 2.630 | 2.898 | 3.122 | 3.488 | 3.780 | 4.235 | 4.582 | 5.131 | 5.636 | 6.190 |
| 1.2500 | 2.995 | 3.373 | 3.803 | 4.131 | 4.401 | 4.837 | 5.185 | 5.724 | 6.149 | 6.847 | 7.482 | 8.124 |
| 1.5000 | 4.154 | 4.585 | 5.069 | 5.436 | 5.739 | 6.224 | 6.608 | 7.203 | 7.680 | 8.480 | 9.178 | 9.833 |
| 1.7500 | 5.421 | 5.878 | 6.390 | 6.778 | 7.098 | 7.609 | 8.011 | 8.631 | 9.135 | 9.972 | 10.661 | 11.263 |
| 2.0000 | 6.757 | 7.215 | 7.779 | 8.119 | 8.440 | 8.955 | 9.356 | 9.970 | 10.470 | 11.275 | 11.890 | 12.390 |
| 2.5000 | 9.455 | 9.853 | 10.301 | 10.639 | 10.919 | 11.366 | 11.712 | 12.231 | 12.633 | 13.196 | 13.543 | 13.775 |
| 3.0000 | 11.806 | 12.095 | 12.411 | 12.645 | 12.837 | 13.138 | 13.370 | 13.699 | 13.912 | 14.117 | 14.185 | 14.200 |
| 3.5000 | 13.180 | 13.381 | 13.593 | 13.741 | 13.854 | 14.016 | 14.117 | 14.199 | 14.200 | 14.200 | 14.200 | 14.200 |
| 4.0000 | 13.343 | 13.515 | 13.721 | 13.863 | 13.968 | 14.109 | 14.182 | 14.200 | 14.200 | 14.200 | 14.200 | 14.200 |
| 5.6636 | 13.343 | 13.515 | 13.721 | 13.863 | 13.968 | 14.109 | 14.182 | 14.200 | 14.200 | 14.200 | 14.200 | 14.200 |
| 6.0000 | 13.343 | 13.515 | 13.721 | 13.863 | 13.968 | 14.109 | 14.182 | 14.200 | 14.200 | 14.200 | 14.200 | 14.200 |
| 6.5666 | 13.343 | 13.515 | 13.721 | 13.863 | 13.968 | 14.109 | 14.182 | 14.200 | 14.200 | 14.200 | 14.200 | 14.200 |
| 7.0000 | 13.226 | 13.424 | 13.633 | 13.780 | 13.890 | 14.045 | 14.137 | 14.200 | 14.200 | 14.200 | 14.200 | 14.200 |
| 7.5000 | 12.333 | 12.600 | 12.896 | 13.112 | 13.283 | 13.542 | 13.727 | 13.966 | 14.094 | 14.191 | 14.200 | 14.200 |
| 8.0000 | 10.632 | 10.995 | 11.400 | 11.703 | 11.949 | 12.388 | 12.635 | 13.066 | 13.358 | 13.706 | 13.870 | 13.920 |
| 8.2533 | 9.501 | 9.905 | 10.340 | 10.696 | 10.972 | 11.410 | 11.760 | 12.276 | 12.665 | 13.119 | 13.363 | 13.448 |
| 8.5000 | 8.204 | 8.647 | 9.132 | 9.495 | 9.792 | 10.270 | 10.655 | 11.237 | 11.666 | 12.236 | 12.545 | 12.678 |
| 8.7500 | 6.771 | 7.230 | 7.740 | 8.115 | 8.430 | 8.932 | 9.335 | 9.956 | 10.417 | 11.035 | 11.382 | 11.560 |
| 9.0000 | 5.250 | 5.715 | 6.226 | 6.607 | 6.920 | 7.428 | 7.834 | 8.458 | 8.918 | 9.530 | 9.881 | 10.077 |
| 9.1250 | 4.478 | 4.935 | 5.440 | 5.815 | 6.126 | 6.628 | 7.027 | 7.637 | 8.083 | 8.670 | 9.014 | 9.212 |
| 9.2500 | 3.711 | 4.155 | 4.640 | 5.010 | 5.313 | 5.801 | 6.186 | 6.775 | 7.200 | 7.757 | 8.080 | 8.270 |
| 9.3750 | 2.967 | 3.385 | 3.846 | 4.220 | 4.486 | 4.984 | 5.322 | 5.875 | 6.272 | 6.787 | 7.085 | 7.261 |
| 9.5000 | 2.244 | 2.630 | 3.061 | 3.387 | 3.657 | 4.091 | 4.430 | 4.940 | 5.301 | 5.760 | 6.032 | 6.184 |
| 9.6250 | 1.570 | 1.910 | 2.291 | 2.589 | 2.839 | 3.215 | 3.518 | 3.970 | 4.292 | 4.700 | 4.925 | 5.046 |
| 9.7500 | 0.974 | 1.265 | 1.586 | 1.820 | 2.020 | 2.337 | 2.590 | 2.975 | 3.248 | 3.588 | 3.762 | 3.846 |
| 9.8750 | 0.540 | 0.792 | 1.070 | 1.268 | 1.426 | 1.667 | 1.852 | 2.128 | 2.319 | 2.568 | 2.682 | 2.706 |
| 10.0000 | | 0.375 | 0.706 | 0.910 | 1.070 | 1.315 | 1.485 | 1.708 | 1.848 | 2.004 | 2.047 | 1.987 |
| 10.0135 | | | 0.170 | 0.655 | 0.874 | 1.184 | 1.356 | 1.560 | 1.726 | 1.820 | 1.830 | 1.710 |
| 10.1270 | | | | | | 0.835 | 1.151 | 1.420 | 1.545 | 1.660 | 1.618 | 1.410 |
| 10.1905 | | | | | | | | 1.030 | 1.280 | 1.370 | 1.273 | 0.935 |
| 10.2540 | | | | | | | | | | 0.625 | 0.523 | |

ORD. OFFSETS




ORD. OFFSETS 作画

B O N J E A N * SQUARE METER, BOTH SIDE (EXT) *

| ORDINATE NO | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE FROM AP | 157.6??M | 162.525M | 167.450M | 172.375M | 177.300M | 179.762M | 182.225M | 184.687M | 187.150M | 189.612M |
| DRAFT EXT (M) | | | | | | | | | | |
| 0.025 | 1.82 | 1.69 | 1.53 | 1.33 | 1.09 | 0.96 | 0.83 | 0.69 | 0.55 | 0.41 |
| 0.150 | 3.86 | 3.60 | 3.27 | 2.05 | 2.36 | 2.08 | 1.80 | 1.50 | 1.21 | 0.92 |
| 0.275 | 7.34 | 6.86 | 6.25 | 5.40 | 4.56 | 4.05 | 3.51 | 2.96 | 2.40 | 1.84 |
| 0.400 | 11.08 | 10.20 | 9.31 | 8.19 | 6.85 | 6.10 | 5.31 | 4.50 | 3.67 | 2.85 |
| 0.525 | 14.49 | 13.60 | 12.43 | 10.97 | 9.21 | 8.23 | 7.19 | 6.11 | 5.01 | 3.92 |
| 0.775 | 21.82 | 20.53 | 18.85 | 16.72 | 14.12 | 12.67 | 11.12 | 9.51 | 7.86 | 6.22 |
| 1.025 | 29.29 | 27.62 | 25.43 | 22.65 | 19.24 | 17.31 | 15.26 | 13.10 | 10.90 | 8.69 |
| 1.525 | 44.53 | 42.17 | 39.02 | 34.98 | 29.95 | 27.09 | 24.01 | 20.76 | 17.41 | 14.04 |
| 2.025 | 60.06 | 57.08 | 53.05 | 47.79 | 41.19 | 37.38 | 33.27 | 28.91 | 24.38 | 19.81 |
| 2.525 | 75.71 | 72.19 | 67.34 | 60.94 | 52.79 | 48.05 | 42.90 | 37.41 | 31.67 | 25.86 |
| 3.025 | 91.56 | 87.56 | 81.96 | 74.46 | 64.78 | 59.10 | 52.90 | 46.25 | 39.28 | 32.19 |
| 3.525 | 107.49 | 103.08 | 96.79 | 88.23 | 77.05 | 70.43 | 63.16 | 55.33 | 47.10 | 38.70 |
| 4.025 | 123.49 | 118.72 | 111.79 | 102.21 | 89.53 | 81.97 | 73.63 | 64.67 | 55.10 | 45.37 |
| 4.525 | 139.53 | 134.45 | 126.91 | 116.35 | 102.20 | 93.70 | 84.28 | 74.06 | 63.25 | 52.14 |
| 5.025 | 155.60 | 150.24 | 142.13 | 130.61 | 115.01 | 105.56 | 95.07 | 83.63 | 71.49 | 59.00 |
| 5.525 | 171.73 | 166.12 | 157.47 | 145.01 | 127.95 | 117.57 | 105.99 | 93.33 | 79.85 | 65.94 |
| 6.025 | 187.83 | 182.00 | 172.82 | 159.43 | 140.95 | 129.64 | 116.97 | 103.08 | 88.25 | 72.89 |
| 6.525 | 203.94 | 197.90 | 188.20 | 173.90 | 154.00 | 141.76 | 128.01 | 112.89 | 96.69 | 79.87 |
| 7.025 | 220.04 | 213.80 | 203.61 | 188.41 | 167.09 | 153.92 | 139.09 | 122.74 | 105.17 | 86.86 |
| 7.525 | 236.15 | 229.71 | 219.03 | 202.92 | 180.20 | 166.11 | 150.21 | 132.62 | 113.67 | 93.86 |
| 8.025 | 252.25 | 245.62 | 234.45 | 217.44 | 193.37 | 178.32 | 161.34 | 142.52 | 122.19 | 100.85 |
| 8.525 | 268.36 | 261.53 | 249.87 | 231.96 | 206.44 | 190.52 | 172.48 | 152.43 | 130.71 | 107.84 |
| 9.025 | 284.46 | 277.44 | 265.29 | 246.48 | 219.56 | 202.73 | 183.62 | 162.35 | 139.24 | 114.82 |
| 9.525 | 300.57 | 293.35 | 280.71 | 261.01 | 232.67 | 214.93 | 194.76 | 172.26 | 147.76 | 121.78 |
| 10.025 | 316.67 | 309.26 | 296.13 | 275.53 | 245.79 | 227.13 | 205.89 | 182.18 | 156.28 | 128.74 |
| 11.025 | 348.88 | 341.08 | 326.97 | 304.57 | 272.02 | 251.53 | 228.16 | 201.99 | 173.32 | 142.62 |
| 12.025 | 381.09 | 372.90 | 357.81 | 333.61 | 298.25 | 275.93 | 250.42 | 221.81 | 190.33 | 156.47 |
| 13.025 | 413.30 | 404.72 | 388.65 | 362.65 | 324.48 | 300.33 | 272.70 | 241.62 | 207.33 | 170.34 |
| 14.025 | 445.44 | 436.47 | 419.42 | 391.63 | 350.66 | 324.69 | 294.94 | 261.42 | 224.37 | 184.31 |
| 15.025 | 477.65 | 468.29 | 450.26 | 420.67 | 376.91 | 349.16 | 317.33 | 281.41 | 241.68 | 198.67 |
| 16.025 | 509.85 | 500.11 | 481.10 | 449.71 | 403.22 | 373.73 | 339.88 | 301.65 | 259.36 | 213.57 |
| 17.025 | 542.06 | 531.92 | 511.93 | 478.75 | 429.61 | 398.46 | 362.67 | 322.26 | 277.58 | 229.21 |
| 18.025 | 574.27 | 563.74 | 542.77 | 507.79 | 456.13 | 423.40 | 385.80 | 343.37 | 296.50 | 245.79 |
| 19.025 | 595.23 | 584.58 | 563.30 | 527.68 | 475.04 | 441.62 | 403.18 | 359.75 | 311.69 | 259.63 |
| 20.025 | 595.23 | 584.58 | 563.30 | 527.68 | 475.04 | 441.62 | 403.18 | 359.75 | 311.69 | 259.63 |
| 21.025 | 595.23 | 584.58 | 563.30 | 527.68 | 475.04 | 441.62 | 403.18 | 359.75 | 311.69 | 259.63 |
| 22.025 | 595.23 | 584.58 | 563.30 | 527.68 | 475.04 | 441.62 | 403.18 | 359.75 | 311.69 | 259.63 |
| UPP.DK.S.L. HEIGHT | 18.326 | 18.335 | 18.360 | 18.404 | 18.464 | 18.501 | 18.542 | 18.587 | 18.634 | 18.685 |
| BONJEAN | 583.97 | 573.61 | 553.11 | 518.81 | 467.84 | 435.38 | 397.94 | 355.52 | 308.45 | 257.34 |
| UPP.DK.C.L. HEIGHT | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 | 18.858 |
| BONJEAN | 595.23 | 584.58 | 563.30 | 527.68 | 475.04 | 441.62 | 403.18 | 359.75 | 311.69 | 259.63 |

ボンジャン(EXT)

G I R T H   L E N G T H   * METER, BOTH SIDE *

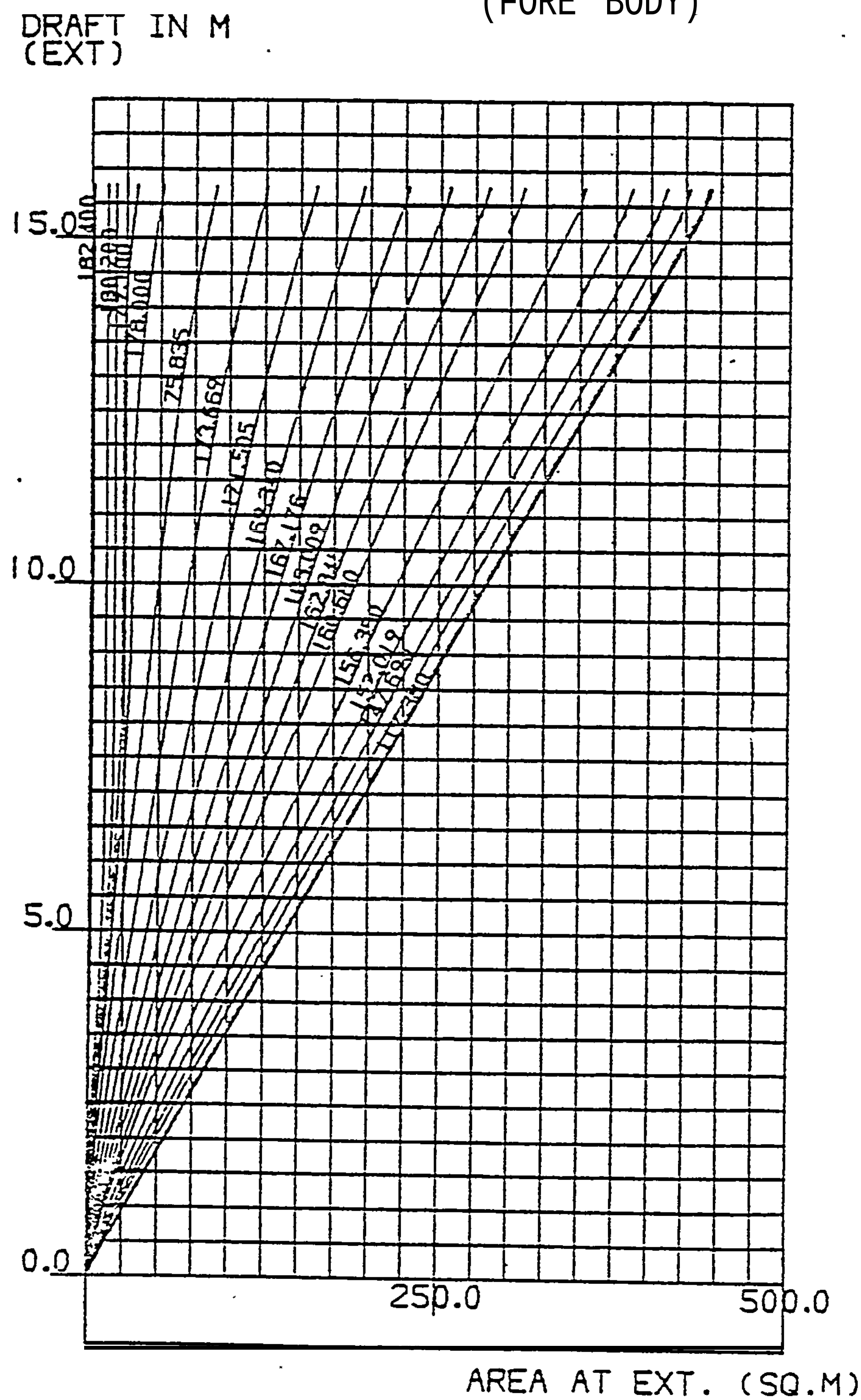
| ORDINATE NO | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE FROM AP | 157.600M | 162.525M | 167.450M | 172.375M | 177.300M | 179.762M | 182.225M | 184.687M | 187.150M | 189.612M |
| DRAFT MLD (M) | | | | | | | | | | |
| 0.050 | 26.768 | 24.952 | 22.607 | 19.703 | 16.255 | 14.357 | 12.373 | 10.333 | 8.275 | 6.244 |
| 0.125 | 27.393 | 25.627 | 23.335 | 20.472 | 17.043 | 15.143 | 13.140 | 11.006 | 9.001 | 6.944 |
| 0.250 | 28.106 | 26.393 | 24.150 | 21.345 | 17.945 | 16.045 | 14.040 | 11.957 | 9.840 | 7.737 |
| 0.375 | 28.663 | 26.918 | 24.795 | 22.024 | 18.651 | 16.755 | 14.742 | 12.643 | 10.499 | 8.369 |
| 0.500 | 29.140 | 27.498 | 25.342 | 22.605 | 19.255 | 17.361 | 15.344 | 13.230 | 11.063 | 8.901 |
| 0.750 | 29.953 | 28.370 | 26.279 | 23.604 | 20.294 | 18.405 | 16.378 | 14.243 | 12.038 | 9.826 |
| 1.000 | 30.653 | 29.125 | 27.093 | 24.469 | 21.190 | 19.304 | 17.271 | 15.116 | 12.882 | 10.632 |
| 1.500 | 31.876 | 30.444 | 28.511 | 25.974 | 22.747 | 20.866 | 18.817 | 16.630 | 14.343 | 12.028 |
| 2.000 | 32.979 | 31.622 | 29.760 | 27.302 | 24.115 | 22.234 | 20.173 | 17.956 | 15.630 | 13.266 |
| 2.500 | 34.028 | 32.723 | 30.931 | 28.572 | 25.365 | 23.404 | 21.410 | 19.170 | 16.812 | 14.411 |
| 3.000 | 35.050 | 33.782 | 32.037 | 29.671 | 26.526 | 24.654 | 22.570 | 20.312 | 17.930 | 15.561 |
| 3.500 | 36.061 | 34.816 | 33.104 | 30.770 | 27.652 | 25.770 | 23.679 | 21.407 | 19.006 | 16.557 |
| 4.000 | 37.066 | 35.836 | 34.146 | 31.835 | 28.729 | 26.847 | 24.750 | 22.468 | 20.053 | 17.589 |
| 4.500 | 38.069 | 36.847 | 35.171 | 32.875 | 29.780 | 27.897 | 25.797 | 23.508 | 21.084 | 18.607 |
| 5.000 | 39.070 | 37.854 | 36.186 | 33.899 | 30.810 | 28.929 | 26.827 | 24.533 | 22.102 | 19.617 |
| 5.500 | 40.070 | 38.857 | 37.194 | 34.912 | 31.827 | 29.947 | 27.845 | 25.549 | 23.112 | 20.621 |
| 6.000 | 41.070 | 39.859 | 38.198 | 35.918 | 32.836 | 30.957 | 28.855 | 26.558 | 24.118 | 21.623 |
| 6.500 | 42.070 | 40.859 | 39.199 | 36.921 | 33.841 | 31.962 | 29.861 | 27.562 | 25.121 | 22.624 |
| 7.000 | 43.070 | 41.859 | 40.200 | 37.922 | 34.843 | 32.964 | 30.864 | 28.565 | 26.123 | 23.624 |
| 7.500 | 44.070 | 42.859 | 41.200 | 38.922 | 35.843 | 33.965 | 31.865 | 29.566 | 27.124 | 24.624 |
| 8.000 | 45.070 | 43.859 | 42.200 | 39.922 | 36.843 | 34.965 | 32.865 | 30.567 | 28.124 | 25.624 |
| 8.500 | 46.070 | 44.859 | 43.200 | 40.922 | 37.843 | 35.965 | 33.865 | 31.567 | 29.124 | 26.624 |
| 9.000 | 47.070 | 45.859 | 44.200 | 41.922 | 38.843 | 36.965 | 34.865 | 32.567 | 30.124 | 27.624 |
| 9.500 | 48.070 | 46.859 | 45.200 | 42.922 | 39.843 | 37.965 | 35.865 | 33.567 | 31.124 | 28.625 |
| 10.000 | 49.070 | 47.859 | 46.200 | 43.922 | 40.843 | 38.965 | 36.865 | 34.567 | 32.124 | 29.625 |
| 11.000 | 51.070 | 49.859 | 48.200 | 45.922 | 42.843 | 40.965 | 38.865 | 36.567 | 34.124 | 31.625 |
| 12.000 | 53.070 | 51.859 | 50.200 | 47.922 | 44.843 | 42.965 | 40.865 | 38.567 | 36.124 | 33.625 |
| 13.000 | 55.070 | 53.859 | 52.200 | 49.922 | 46.843 | 44.965 | 42.865 | 40.567 | 38.125 | 35.627 |
| 14.000 | 57.070 | 55.859 | 54.200 | 51.922 | 48.843 | 46.966 | 44.866 | 42.569 | 40.130 | 37.642 |
| 15.000 | 59.070 | 57.859 | 56.200 | 53.922 | 50.843 | 48.967 | 46.870 | 44.578 | 42.152 | 39.691 |
| 16.000 | 61.070 | 59.859 | 58.200 | 55.922 | 52.845 | 50.971 | 48.880 | 46.602 | 44.204 | 41.792 |
| 17.000 | 63.070 | 61.859 | 60.200 | 57.922 | 54.847 | 52.979 | 50.901 | 48.650 | 46.298 | 43.961 |
| 18.000 | 65.070 | 63.859 | 62.200 | 59.922 | 56.853 | 54.995 | 52.938 | 50.728 | 48.444 | 46.208 |
| 19.000 | 67.672 | 66.479 | 64.870 | 62.680 | 59.740 | 57.972 | 56.035 | 53.989 | 51.925 | 49.978 |
| 20.000 | 67.672 | 66.479 | 64.870 | 62.680 | 59.740 | 57.972 | 56.035 | 53.989 | 51.925 | 49.978 |
| 21.000 | 67.672 | 66.479 | 64.870 | 62.680 | 59.740 | 57.972 | 56.035 | 53.989 | 51.925 | 49.978 |
| 22.000 | 67.672 | 66.479 | 64.870 | 62.680 | 59.740 | 57.972 | 56.035 | 53.989 | 51.925 | 49.978 |
| UPP.DK.S.L. HEIGHT | 18.361 | 18.310 | 18.335 | 18.379 | 18.439 | 18.476 | 18.517 | 18.562 | 18.609 | 18.660 |
| GIRTH | 67.672 | 66.479 | 64.870 | 62.680 | 59.740 | 57.972 | 56.035 | 53.989 | 51.925 | 49.978 |

ボンジャン(MLD)

ボンジャン(作画)

# BONJEAN CURVES

(FORE BODY)



***** APPEN MAP VOLUME *****

SONNAR DOOM 1 COMPARTMENT NO. = 1

| W.L. | VOLUME | | K.G.HT. | C.L.HT. | LCB HT. | W.P.A. | LCF HT. | CL.F HT. | I.(TRV.) | I.(LONG) |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.900 | 0.20 | 0. | -1. | -0. | 29. | 7. | 962. | -0. | 3. | 137670. |
| -2.800 | 1.11 | 0. | -3. | -0. | 158. | 11. | 1523. | -0. | 8. | 237650. |
| -2.600 | 3.71 | 0. | -10. | -0. | 529. | 16. | 2321. | -0. | 19. | 330737. |
| -2.500 | 5.45 | 0. | -15. | -0. | 778. | 18. | 2633. | -0. | 25. | 374847. |
| -2.400 | 7.43 | 0. | -19. | -0. | 1059. | 21. | 3044. | -0. | 31. | 432545. |
| -2.200 | 12.10 | 0. | -30. | -0. | 1723. | 26. | 3629. | -0. | 42. | 514691. |
| -2.000 | 17.58 | 0. | -42. | -0. | 2498. | 29. | 4088. | -0. | 52. | 578938. |
| -1.800 | 23.68 | 0. | -53. | -0. | 3362. | 32. | 4572. | -0. | 61. | 646281. |
| -1.600 | 30.38 | 0. | -65. | -0. | 4308. | 34. | 4869. | -0. | 68. | 687667. |
| -1.500 | 33.90 | 0. | -70. | -0. | 4805. | 36. | 5074. | -0. | 71. | 715846. |
| -1.400 | 37.54 | 0. | -75. | -0. | 5319. | 37. | 5208. | -0. | 73. | 734341. |
| -1.200 | 45.07 | 0. | -85. | -0. | 6379. | 38. | 5381. | -0. | 76. | 758184. |
| -1.000 | 52.84 | 0. | -94. | -0. | 7472. | 40. | 5565. | -0. | 77. | 783100. |
| -0.800 | 60.79 | 0. | -101. | -0. | 8592. | 40. | 5614. | -0. | 75. | 789540. |
| -0.600 | 68.76 | 0. | -106. | -0. | 9711. | 40. | 5566. | -0. | 71. | 782359. |
| -0.500 | 72.70 | 0. | -109. | -0. | 10264. | 39. | 5505. | -0. | 68. | 773665. |
| -0.400 | 76.59 | 0. | -110. | -0. | 10811. | 39. | 5425. | -0. | 64. | 762357. |
| -0.200 | 84.14 | 0. | -113. | -0. | 11872. | 37. | 5166. | -0. | 55. | 725967. |
| 0.0 | 91.23 | 0. | -113. | -0. | 12868. | 34. | 4781. | -0. | 44. | 671874. |
| 0.050 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.100 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.150 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.250 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.375 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.500 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 0.750 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 1.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 1.250 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 1.500 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 1.750 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 2.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 2.500 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 3.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 3.500 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 4.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 4.500 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 4.850 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 5.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 5.150 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 5.350 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 6.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 7.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 8.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 8.221 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 8.300 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 9.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 9.590 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 10.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 11.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 12.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 13.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |
| 14.000 | 91.23 | 0. | -113. | -0. | 12868. | 0. | 0. | 0. | 0. | 0. |

排水量(MAP APPEN)

DATA FOR HYDROSTATIC CURVES ◆ METRIC SYSTEM ◆

| DRAFT (EXT) (M) | DISPT (MT) | DISPT (MLD) (MT) | APPEN (MT) | D.CORR (MT) | M T C (MT-M) | T P C (MT) | K B (M) | L C B (M) | L C F (M) | T KM (M) | L KM (M) | T C B (M) | T C F (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.073 | 211.49 | 156.72 | 54.76 | 24.31 | 330.52 | 31.95 | 0.025 | -5.510 | -5.524 | 961.546 | 27069.039 | -0.001 | -0.000 |
| 0.149 | 456.78 | 400.37 | 56.55 | 26.09 | 297.22 | 32.95 | 0.063 | -5.531 | -5.564 | 400.004 | 11269.984 | 0.001 | -0.000 |
| 0.273 | 877.09 | 819.29 | 58.60 | 27.17 | 297.71 | 34.04 | 0.127 | -5.551 | -5.581 | 200.442 | 5873.617 | -0.000 | -0.000 |
| 0.399 | 1310.21 | 1250.00 | 60.22 | 27.81 | 305.15 | 34.85 | 0.191 | -5.564 | -5.592 | 143.217 | 4034.061 | -0.000 | -0.000 |
| 0.523 | 1751.39 | 1649.70 | 61.60 | 28.27 | 312.60 | 35.49 | 0.255 | -5.572 | -5.601 | 109.939 | 3091.839 | -0.000 | -0.000 |
| 0.773 | 2654.34 | 2590.33 | 64.00 | 28.95 | 327.45 | 36.52 | 0.384 | -5.591 | -5.634 | 75.961 | 2137.078 | -0.000 | -0.000 |
| 1.023 | 3579.56 | 3512.60 | 66.06 | 29.40 | 339.30 | 37.24 | 0.513 | -5.602 | -5.624 | 58.305 | 1643.057 | -0.000 | -0.000 |
| 1.523 | 5471.48 | 5401.60 | 69.01 | 29.96 | 359.14 | 38.25 | 0.771 | -5.619 | -5.653 | 40.066 | 1137.626 | -0.000 | -0.000 |
| 2.023 | 7405.43 | 7332.17 | 73.25 | 30.32 | 373.43 | 38.94 | 1.029 | -5.622 | -5.595 | 30.863 | 874.420 | -0.000 | -0.000 |
| 3.023 | 11356.11 | 11277.29 | 78.89 | 30.80 | 393.85 | 39.40 | 1.544 | -5.576 | -5.367 | 21.764 | 602.726 | -0.000 | -0.000 |
| 4.023 | 15383.93 | 15299.64 | 84.33 | 31.10 | 407.76 | 40.57 | 2.059 | -5.476 | -5.010 | 17.372 | 461.132 | -0.000 | -0.000 |
| 5.023 | 19456.54 | 19374.80 | 89.78 | 31.31 | 418.34 | 40.97 | 2.572 | -5.327 | -4.509 | 14.847 | 374.817 | -0.000 | -0.000 |
| 6.023 | 23586.47 | 23491.25 | 95.22 | 31.47 | 427.72 | 41.35 | 3.046 | -5.130 | -3.868 | 13.404 | 317.171 | -0.000 | -0.003 |
| 7.023 | 27744.91 | 27645.87 | 101.03 | 31.63 | 430.40 | 41.75 | 3.599 | -4.002 | -3.001 | 12.489 | 277.307 | -0.006 | -0.000 |
| 8.023 | 31951.37 | 31844.67 | 106.91 | 31.78 | 452.87 | 42.24 | 4.113 | -4.582 | -2.126 | 11.941 | 249.598 | -0.000 | -0.000 |
| 9.023 | 36[illegible].51 | 36099.64 | 112.87 | 31.94 | 473.67 | 42.68 | 4.631 | -4.221 | -0.903 | 11.647 | 231.181 | -0.000 | -0.000 |
| 10.023 | 40549.77 | 40421.83 | 118.95 | 32.10 | 496.60 | 43.57 | 5.151 | -3.799 | 0.373 | 11.517 | 217.311 | -0.000 | -0.000 |
| 11.023 | 44930.27 | 44815.47 | 124.78 | 32.25 | 521.58 | 44.30 | 5.676 | -3.332 | 1.499 | 11.518 | 206.693 | -0.000 | -0.000 |
| 12.023 | 49411.14 | 49280.57 | 130.57 | 32.40 | 545.35 | 45.00 | 6.204 | -2.855 | 2.333 | 11.614 | 197.435 | -0.000 | -0.000 |
| 13.023 | 53950.60 | 53813.80 | 136.29 | 32.54 | 567.87 | 45.66 | 6.734 | -2.390 | 2.953 | 11.705 | 189.043 | -0.000 | -0.000 |
| 14.023 | 58551.50 | 58413.49 | 142.03 | 32.68 | 591.17 | 46.33 | 7.267 | -1.952 | 3.349 | 12.014 | 182.129 | -0.000 | -0.000 |
| 15.023 | 63[illegible].77 | 63077.49 | 147.73 | 32.74 | 613.05 | 46.90 | 7.802 | -1.552 | 3.543 | 12.267 | 175.741 | -0.000 | -0.000 |

排水量(BANK ½)

DATA FOR HYDROSTATIC CURVES * METRIC SYSTEM *

| DRAFT (EXT) (M) | C B | C P | C W | C M | A W (SQ.M) | A M (SQ.M) | W S A (SQ.M) |
|---|---|---|---|---|---|---|---|
| 0.073 | 0.6217 | 0.6683 | 0.6336 | 0.9303 | 3116.78 | 1.32 | 3117.17 |
| 0.148 | 0.6350 | 0.6760 | 0.6535 | 0.9394 | 3214.29 | 3.33 | 3218.94 |
| 0.273 | 0.6500 | 0.6843 | 0.6752 | 0.9499 | 3321.02 | 6.74 | 3335.26 |
| 0.398 | 0.6611 | 0.6907 | 0.6913 | 0.9571 | 3400.30 | 10.19 | 3427.63 |
| 0.523 | 0.6703 | 0.6961 | 0.7049 | 0.9629 | 3462.70 | 13.67 | 3506.00 |
| 0.773 | 0.6850 | 0.7050 | 0.7243 | 0.9717 | 3567.60 | 20.70 | 3643.02 |
| 1.023 | 0.6967 | 0.7175 | 0.7387 | 0.9778 | 3633.35 | 27.77 | 3760.47 |
| 1.523 | 0.7142 | 0.7250 | 0.7587 | 0.9851 | 3731.82 | 41.97 | 3973.52 |
| 2.023 | 0.7271 | 0.7353 | 0.7724 | 0.9888 | 3799.34 | 56.17 | 4169.66 |
| 3.023 | 0.7456 | 0.7512 | 0.7913 | 0.9926 | 3892.28 | 84.57 | 4542.49 |
| 4.023 | 0.7586 | 0.7629 | 0.8034 | 0.9944 | 3952.07 | 112.97 | 4904.03 |
| 5.023 | 0.7686 | 0.7720 | 0.8126 | 0.9955 | 3997.13 | 141.37 | 5261.87 |
| 6.023 | 0.7765 | 0.7794 | 0.8[illegible]02 | 0.9963 | 4034.36 | 169.77 | 5619.37 |
| 7.023 | 0.7833 | 0.7858 | 0.8201 | 0.9968 | 4073.46 | 198.17 | 5977.66 |
| 8.023 | 0.7895 | 0.7917 | 0.8378 | 0.9972 | 4120.91 | 226.57 | 6339.36 |
| 9.023 | 0.7956 | 0.7975 | 0.8505 | 0.9975 | 4183.46 | 254.97 | 6720.34 |
| 10.023 | 0.8017 | 0.8035 | 0.8641 | 0.9978 | 4250.58 | 283.37 | 7102.56 |
| 11.023 | 0.8081 | 0.8097 | 0.8786 | 0.9980 | 4321.75 | 311.77 | 7487.03 |
| 12.023 | 0.8145 | 0.8160 | 0.8935 | 0.9981 | 4390.25 | 340.17 | 7867.54 |
| 13.023 | 0.8210 | 0.8224 | 0.9055 | 0.9983 | 4454.59 | 368.57 | 8243.90 |
| 14.023 | 0.8276 | 0.8289 | 0.9189 | 0.9984 | 4520.14 | 396.97 | 8623.29 |
| 15.023 | 0.8341 | 0.8353 | 0.9302 | 0.9985 | 4575.70 | 425.36 | 9000.57 |

排水量(BANK 2/2)

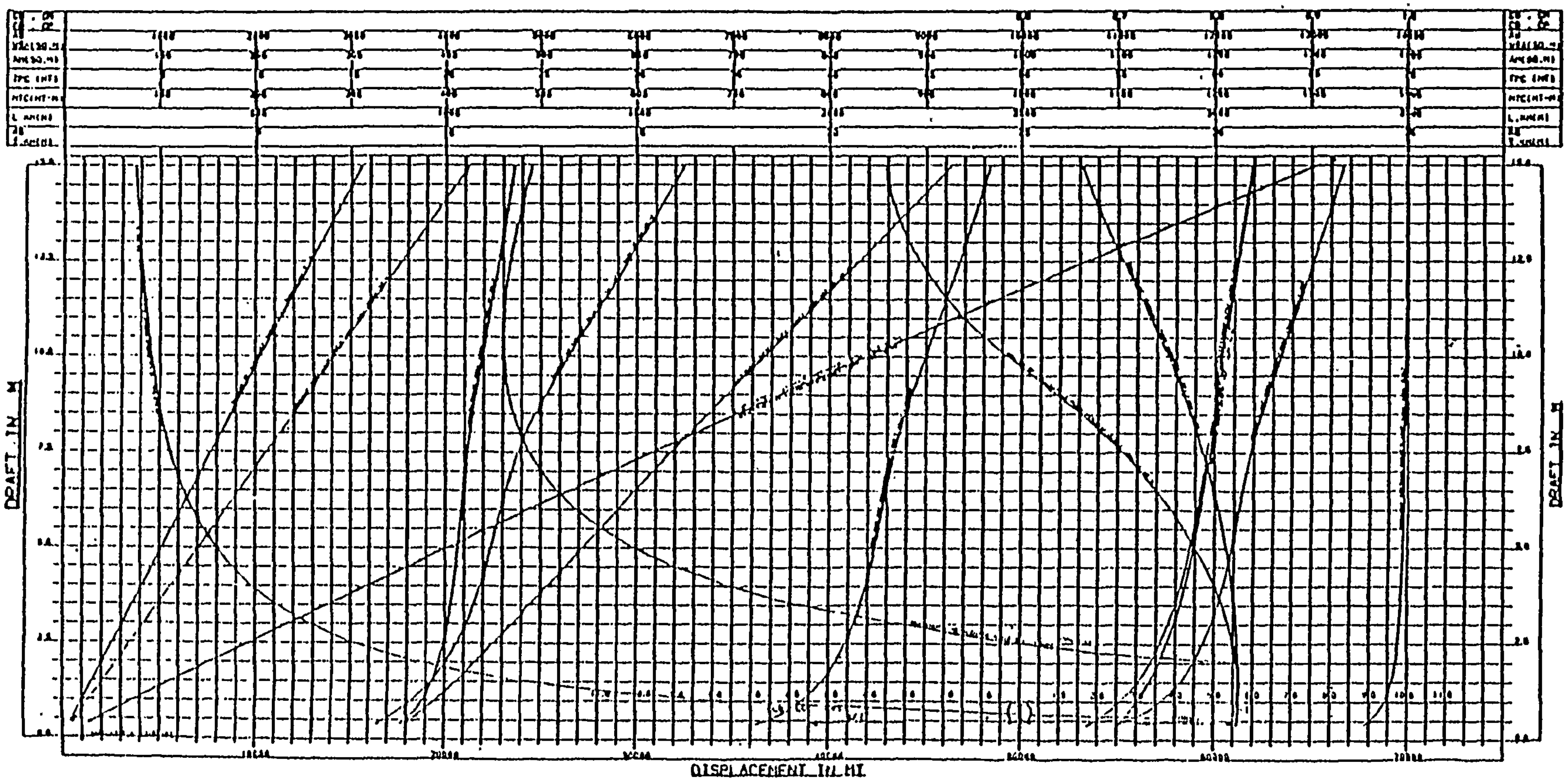
# 排水量テーブル (1/2)

| DRAFT (EXT) (M) | DISPT (MT) | DIFF (MT) | D.CORR. (MT) | M T C (MT-M) | L C B (M) | L C F (M) | T KM (M) |
|---|---|---|---|---|---|---|---|
| 2.00 | 9398. | 0.0 | 39.10 | 542.63 | -9.17 | -8.76 | 39.27 |
| 2.10 | 9899. | 501.00 | 39.18 | 546.40 | -9.15 | -8.72 | 37.62 |
| 2.20 | 10401. | 502.00 | 39.25 | 549.97 | -9.13 | -8.68 | 36.09 |
| 2.30 | 10904. | 503.00 | 39.32 | 553.38 | -9.11 | -8.64 | 34.68 |
| 2.40 | 11409. | 505.00 | 39.38 | 556.65 | -9.09 | -8.60 | 33.39 |
| 2.50 | 11915. | 506.00 | 39.45 | 559.80 | -9.06 | -8.56 | 32.20 |
| 2.60 | 12424. | 509.00 | 39.51 | 562.83 | -9.04 | -8.52 | 31.12 |
| 2.70 | 12934. | 510.00 | 39.56 | 565.75 | -9.02 | -8.48 | 30.11 |
| 2.80 | 13446. | 512.00 | 39.62 | 568.54 | -9.00 | -8.44 | 29.18 |
| 2.90 | 13959. | 513.00 | 39.67 | 571.24 | -8.98 | -8.40 | 28.31 |
| 3.00 | 14473. | 514.00 | 39.72 | 573.85 | -8.96 | -8.36 | 27.50 |
| 3.10 | 14988. | 515.00 | 39.77 | 576.37 | -8.94 | -8.32 | 26.75 |
| 3.20 | 15504. | 516.00 | 39.82 | 578.81 | -8.92 | -8.28 | 26.04 |
| 3.30 | 16021. | 517.00 | 39.86 | 581.17 | -8.89 | -8.24 | 25.39 |
| 3.40 | 16539. | 518.00 | 39.91 | 583.44 | -8.87 | -8.19 | 24.77 |
| 3.50 | 17058. | 519.00 | 39.95 | 585.66 | -8.85 | -8.15 | 24.19 |
| 3.60 | 17577. | 519.00 | 39.99 | 587.82 | -8.83 | -8.11 | 23.64 |
| 3.70 | 18097. | 520.00 | 40.02 | 589.90 | -8.81 | -8.07 | 23.12 |
| 3.80 | 18619. | 522.00 | 40.06 | 591.93 | -8.79 | -8.02 | 22.64 |
| 3.90 | 19140. | 521.00 | 40.10 | 593.90 | -8.77 | -7.98 | 22.18 |
| 4.00 | 19663. | 523.00 | 40.13 | 595.83 | -8.74 | -7.93 | 21.74 |
| 4.10 | 20186. | 523.00 | 40.16 | 597.72 | -8.72 | -7.89 | 21.33 |
| 4.20 | 20710. | 524.00 | 40.20 | 599.55 | -8.70 | -7.84 | 20.94 |
| 4.30 | 21235. | 525.00 | 40.23 | 601.34 | -8.68 | -7.79 | 20.57 |
| 4.40 | 21761. | 526.00 | 40.26 | 603.09 | -8.66 | -7.74 | 20.22 |
| 4.50 | 22287. | 526.00 | 40.29 | 604.79 | -8.63 | -7.70 | 19.89 |
| 4.60 | 22813. | 526.00 | 40.32 | 606.46 | -8.61 | -7.65 | 19.57 |
| 4.70 | 23340. | 527.00 | 40.34 | 608.09 | -8.59 | -7.60 | 19.26 |
| 4.80 | 23868. | 528.00 | 40.37 | 609.68 | -8.57 | -7.54 | 18.98 |
| 4.90 | 24397. | 529.00 | 40.40 | 611.24 | -8.54 | -7.49 | 18.70 |
| 5.00 | 24926. | 529.00 | 40.42 | 612.76 | -8.52 | -7.44 | 18.44 |
| 5.10 | 25457. | 531.00 | 40.45 | 614.20 | -8.50 | -7.38 | 18.19 |
| 5.20 | 25989. | 532.00 | 40.47 | 615.80 | -8.48 | -7.33 | 17.95 |
| 5.30 | 26521. | 532.00 | 40.50 | 617.28 | -8.45 | -7.27 | 17.72 |
| 5.40 | 27054. | 533.00 | 40.52 | 618.74 | -8.43 | -7.22 | 17.50 |
| 5.50 | 27587. | 533.00 | 40.54 | 620.18 | -8.40 | -7.16 | 17.29 |
| 5.60 | 28120. | 533.00 | 40.56 | 621.59 | -8.38 | -7.10 | 17.09 |
| 5.70 | 28653. | 533.00 | 40.58 | 622.99 | -8.36 | -7.04 | 16.90 |
| 5.80 | 29186. | 533.00 | 40.60 | 624.36 | -8.33 | -6.98 | 16.72 |
| 5.90 | 29720. | 534.00 | 40.62 | 625.72 | -8.31 | -6.92 | 16.54 |
| 6.00 | 30254. | 534.00 | 40.64 | 627.08 | -8.28 | -6.85 | 16.38 |
| 6.10 | 30789. | 535.00 | 40.66 | 628.43 | -8.26 | -6.79 | 16.21 |
| 6.20 | 31324. | 535.00 | 40.68 | 629.77 | -8.23 | -6.72 | 16.06 |
| 6.30 | 31859. | 535.00 | 40.70 | 631.10 | -8.20 | -6.66 | 15.91 |
| 6.40 | 32396. | 537.00 | 40.72 | 632.42 | -8.18 | -6.59 | 15.77 |
| 6.50 | 32932. | 536.00 | 40.74 | 633.74 | -8.15 | -6.52 | 15.64 |
| 6.60 | 33469. | 537.00 | 40.76 | 635.04 | -8.12 | -6.45 | 15.51 |
| 6.70 | 34007. | 538.00 | 40.78 | 636.35 | -8.10 | -6.38 | 15.38 |
| 6.80 | 34544. | 537.00 | 40.79 | 637.61 | -8.07 | -6.31 | 15.26 |
| 6.90 | 35083. | 539.00 | 40.81 | 638.91 | -8.04 | -6.23 | 15.15 |
| 7.00 | 35622. | 539.00 | 40.83 | 640.23 | -8.01 | -6.15 | 15.04 |

排水量テーブル (2/2)

| DRAFT (EXT) (M) | DISPT (MLD) (MT) | T P C (MT) | W S A (SQ.M) | A M (SQ.M) | A W (SQ.M) | K B (M) | L KM (M) | C B | C P | C W | C M |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.00 | 9291. | 50.12 | 5256.3 | 62.0 | 4889.4 | 1.02 | 1138.3 | 0.7240 | 0.7424 | 0.7730 | 0.9752 |
| 2.50 | 11921. | 50.81 | 5473.8 | 78.1 | 4957.2 | 1.27 | 926.8 | 0.7346 | 0.7494 | 0.7115 | 0.9802 |
| 3.00 | 14376. | 51.37 | 5685.9 | 94.2 | 5017.0 | 1.53 | 782.6 | 0.7432 | 0.7556 | 0.7901 | 0.9836 |
| 3.50 | 16957. | 51.84 | 5894.2 | 110.3 | 5057.3 | 1.79 | 678.2 | 0.7505 | 0.7612 | 0.7972 | 0.9859 |
| 4.00 | 19559. | 52.23 | 6100.1 | 126.4 | 5095.5 | 2.05 | 599.0 | 0.7568 | 0.7662 | 0.8033 | 0.9877 |
| 4.50 | 22179. | 52.57 | 6304.5 | 142.5 | 5128.6 | 2.30 | 536.9 | 0.7623 | 0.7707 | 0.8085 | 0.9891 |
| 5.00 | 24815. | 52.87 | 6507.9 | 158.6 | 5157.6 | 2.56 | 486.9 | 0.7671 | 0.7747 | 0.8131 | 0.9902 |
| 5.50 | 27469. | 53.13 | 6710.9 | 174.7 | 5183.7 | 2.82 | 445.7 | 0.7715 | 0.7785 | 0.8172 | 0.9911 |
| 6.00 | 30129. | 53.38 | 6913.8 | 190.8 | 5207.6 | 3.07 | 411.4 | 0.7755 | 0.7819 | 0.8209 | 0.9918 |
| 6.50 | 32803. | 53.61 | 7116.7 | 206.9 | 5230.0 | 3.33 | 382.4 | 0.7791 | 0.7851 | 0.8245 | 0.9925 |
| 7.[illegible] | 35489. | 53.83 | 732[illegible] | 223.0 | 5251.4 | 3.59 | 357.7 | 0.7825 | 0.7880 | 0.8278 | 0.9930 |
| 7.50 | 38186. | 54.05 | 7542.9 | 239.1 | 5273.2 | 3.84 | 336.5 | 0.7857 | 0.7908 | 0.8313 | 0.9935 |
| 8.00 | 40894. | 54.29 | 7743.2 | 255.2 | 5296.9 | 4.10 | 318.6 | 0.7886 | 0.7935 | 0.8350 | 0.9939 |
| 8.50 | 43615. | 54.56 | 7948.9 | 271.3 | 5322.7 | 4.36 | 303.4 | 0.7915 | 0.7961 | 0.8391 | 0.9942 |
| 9.00 | 46350. | 54.86 | 8156.6 | 287.4 | 5351.8 | 4.62 | 290.5 | 0.7943 | 0.7986 | 0.8437 | 0.9946 |
| 9.50 | 49102. | 55.19 | 8377.2 | 303.5 | 5384.4 | 4.88 | 279.7 | 0.7970 | 0.8012 | 0.8488 | 0.9948 |
| 10.00 | 51869. | 55.52 | 8589.4 | 319.6 | 5416.6 | 5.13 | 269.9 | 0.7997 | 0.8037 | 0.8539 | 0.9951 |
| 10.50 | 54654. | 55.86 | 8803.8 | 335.7 | 5449.6 | 5.39 | 261.2 | 0.8024 | 0.8062 | 0.8591 | 0.9953 |
| 11.00 | 57455. | 56.20 | 9019.4 | 351.8 | 5483.2 | 5.65 | 253.4 | 0.8051 | 0.8087 | 0.8644 | 0.9955 |
| 11.50 | 60274. | 56.55 | 9235.5 | 367.9 | 5517.1 | 5.91 | 246.4 | 0.8078 | 0.8113 | 0.8697 | 0.9957 |
| 12.00 | 63110. | 56.90 | 9451.8 | 384.0 | 5551.2 | 6.18 | 240.0 | 0.8105 | 0.8139 | 0.8751 | 0.9959 |
| 12.50 | 65963. | 57.25 | 9667.7 | 400.1 | 5585.0 | 6.44 | 234.1 | 0.8132 | 0.8164 | 0.8804 | 0.9961 |
| 13.00 | 68834. | 57.59 | 9883.3 | 416.2 | 5618.8 | 6.70 | 228.7 | 0.8159 | 0.8190 | 0.8858 | 0.9962 |
| 13.50 | 71722. | 57.94 | 10097.5 | 432.3 | 5652.8 | 6.96 | 223.7 | 0.8186 | 0.8216 | 0.8911 | 0.9964 |
| 14.00 | 74628. | 58.29 | 10311.4 | 448.4 | 5686.5 | 7.23 | 219.0 | 0.8213 | 0.8242 | 0.8964 | 0.9965 |
| 14.50 | 77550. | 58.62 | 10526.2 | 464.5 | 5718.9 | 7.49 | 214.6 | 0.8240 | 0.8268 | 0.9015 | 0.9966 |
| 15.00 | 80492. | 58.95 | 10741.1 | 480.6 | 5751.0 | 7.75 | 210.4 | 0.8267 | 0.8294 | 0.9066 | 0.9967 |
| 15.50 | 83445. | 59.20 | 10954.0 | 496.7 | 5783.7 | 8.02 | 206.6 | 0.8293 | 0.8319 | 0.9118 | 0.9968 |
| 16.00 | 86417. | 59.62 | 11168.9 | 512.8 | 5816.4 | 8.28 | 203.1 | 0.8320 | 0.8345 | 0.9169 | 0.9969 |

HYDROSTATIC CURVES




排水量等曲線

STABILITY CROSS CURVES ** ASSUMED KG = 7.000 M **

SUBMERGED DISPLACEMENT 98649.75 MT

UNDER UPPER DECK

| ANGLE 0.0 DEG. | | ANGLE 5.0 DEG. | | ANGLE 10.0 DEG. | | ANGLE 15.0 DEG. | | ANGLE 20.0 DEG. | |
|---|---|---|---|---|---|---|---|---|---|
| DISPT (T) | G*Z (M) | DISPT (T) | G*Z (M) | DISPT (T) | G*Z (M) | DISPT (T) | G*Z (M) | DISPT (T) | G*Z (M) |
| 5749.99 | 0.0 | 1417.73 | 13.782 | 932.27 | 15.431 | 790.97 | 15.365 | 737.02 | 14.787 |
| 11499.97 | 0.0 | 5670.91 | 6.250 | 3729.00 | 12.381 | 3163.88 | 13.224 | 2948.07 | 13.175 |
| 17249.96 | 0.0 | 12219.37 | 3.697 | 8393.43 | 9.331 | 7118.70 | 11.383 | 6633.16 | 11.562 |
| 22999.96 | 0.0 | 18975.46 | 2.398 | 14916.30 | 6.281 | 12655.49 | 8.941 | 11792.26 | 9.949 |
| 28749.96 | 0.0 | 25731.57 | 1.719 | 22666.68 | 3.984 | 19774.71 | 6.800 | 18425.43 | 8.337 |
| 34499.96 | 0.0 | 32407.68 | 1.249 | 30444.47 | 2.912 | 28337.13 | 4.788 | 26532.65 | 6.724 |
| 40249.96 | 0.0 | 39243.75 | 1.129 | 38222.23 | 2.336 | 37168.56 | 3.658 | 36064.23 | 5.148 |
| 45999.96 | 0.0 | 45999.86 | 0.972 | 45999.95 | 2.004 | 45999.95 | 3.057 | 45999.87 | 4.178 |
| 51749.93 | 0.0 | 52755.98 | 0.907 | 53777.72 | 1.811 | 54831.28 | 2.730 | 55935.47 | 3.684 |
| 57499.96 | 0.0 | 59512.06 | 0.855 | 61555.37 | 1.703 | 63662.69 | 2.562 | 65610.37 | 3.374 |
| 63249.96 | 0.0 | 66268.12 | 0.827 | 69333.12 | 1.653 | 72340.37 | 2.454 | 74361.62 | 3.018 |
| 68999.94 | 0.0 | 73024.25 | 0.817 | 77098.00 | 1.639 | 80187.00 | 2.236 | 82119.50 | 2.635 |
| 74749.94 | 0.0 | 79780.25 | 0.818 | 84269.94 | 1.528 | 87074.62 | 1.943 | 88584.19 | 2.222 |
| 80499.87 | 0.0 | 86473.19 | 0.815 | 90558.44 | 1.300 | 92605.75 | 1.577 | 93574.81 | 1.814 |
| 86249.81 | 0.0 | 92453.62 | 0.687 | 95463.44 | 0.983 | 96555.12 | 1.214 | 97091.44 | 1.465 |
| 98649.75 | 0.0 | 98649.75 | 0.325 | 98649.75 | 0.648 | 98649.75 | 0.966 | 98649.75 | 1.277 |

INFLOW ANGLE

| DISPT | DISPT | DISPT | DISPT | DISPT |
|---|---|---|---|---|
| 91999.01 | 83950.96 | 75777.75 | 67340.62 | 58514.70 |

** FOR REFERENCE **

INFLOW ANGLE 14.03 DEG
AT DISPT 68999.87 MT

X = 20.000 M FROM A.P.
Y = 20.000 M FROM C.L.
Z = 20.000 M FROM B.L.

G Z ( BANK )

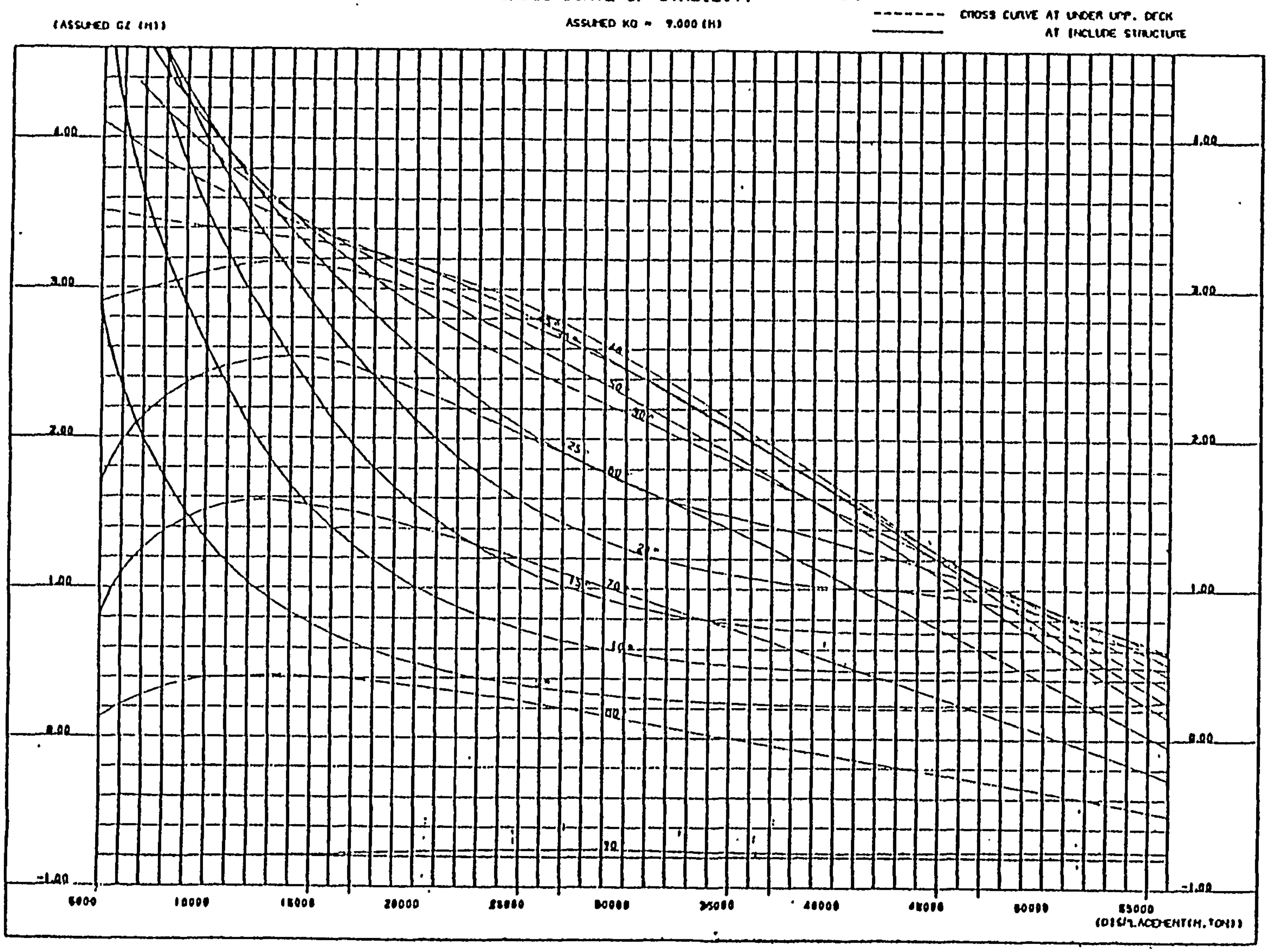
GZテーブル

RIGHTING LEVER (G*Z) TABLE ** UNIT - METER **

UNDER UPPER DECK

| INCLIN.ANGLE | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
|---|---|---|---|---|---|---|---|
| VALUE OF SIN | 0.087 | 0.174 | 0.259 | 0.342 | 0.423 | 0.500 | 0.574 |
| DISPT (MT) | | | | | | | |
| 10000. | 1.337 | 2.409 | 3.545 | 3.985 | 4.122 | 4.083 | 3.928 |
| 10500. | 1.249 | 2.474 | 3.398 | 3.860 | 4.017 | 4.000 | 3.869 |
| 11000. | 1.175 | 2.338 | 3.252 | 3.740 | 3.918 | 3.921 | 3.811 |
| 11500. | 1.101 | 2.212 | 3.121 | 3.625 | 3.822 | 3.846 | 3.757 |
| 12000. | 1.036 | 2.093 | 2.996 | 3.511 | 3.737 | 3.774 | 3.705 |
| 12500. | 0.981 | 1.980 | 2.865 | 3.404 | 3.642 | 3.703 | 3.653 |
| 13000. | 0.929 | 1.877 | 2.747 | 3.298 | 3.558 | 3.637 | 3.605 |
| 13500. | 0.884 | 1.781 | 2.638 | 3.196 | 3.476 | 3.572 | 3.557 |
| 14000. | 0.839 | 1.690 | 2.530 | 3.098 | 3.393 | 3.508 | 3.510 |
| 14500. | 0.800 | 1.608 | 2.422 | 3.003 | 3.317 | 3.448 | 3.467 |
| 15000. | 0.762 | 1.532 | 2.321 | 2.908 | 3.242 | 3.388 | 3.424 |
| 15500. | 0.728 | 1.466 | 2.224 | 2.820 | 3.167 | 3.330 | 3.381 |
| 16000. | 0.695 | 1.401 | 2.133 | 2.733 | 3.097 | 3.275 | 3.341 |
| 16500. | 0.663 | 1.343 | 2.042 | 2.647 | 3.027 | 3.220 | 3.302 |
| 17000. | 0.633 | 1.286 | 1.961 | 2.567 | 2.957 | 3.166 | 3.263 |
| 17500. | 0.606 | 1.233 | 1.882 | 2.488 | 2.893 | 3.116 | 3.230 |
| 18000. | 0.582 | 1.184 | 1.803 | 2.413 | 2.828 | 3.066 | 3.196 |
| 18500. | 0.558 | 1.134 | 1.734 | 2.339 | 2.764 | 3.019 | 3.163 |
| 19000. | 0.537 | 1.092 | 1.671 | 2.266 | 2.700 | 2.972 | 3.132 |
| 19500. | 0.516 | 1.050 | 1.613 | 2.195 | 2.641 | 2.926 | 3.102 |
| 20000. | 0.498 | 1.008 | 1.554 | 2.126 | 2.582 | 2.882 | 3.074 |
| 20500. | 0.480 | 0.972 | 1.503 | 2.062 | 2.523 | 2.839 | 3.046 |
| 21000. | 0.462 | 0.938 | 1.453 | 1.998 | 2.469 | 2.796 | 3.017 |
| 21500. | 0.445 | 0.907 | 1.403 | 1.935 | 2.415 | 2.754 | 2.989 |
| 22000. | 0.431 | 0.874 | 1.359 | 1.878 | 2.361 | 2.715 | 2.961 |
| 22500. | 0.416 | 0.849 | 1.316 | 1.823 | 2.310 | 2.676 | 2.933 |
| 23000. | 0.402 | 0.821 | 1.273 | 1.767 | 2.261 | 2.636 | 2.905 |
| 23500. | 0.389 | 0.796 | 1.236 | 1.717 | 2.212 | 2.597 | 2.875 |
| 24000. | 0.377 | 0.773 | 1.200 | 1.668 | 2.165 | 2.561 | 2.845 |
| 24500. | 0.367 | 0.750 | 1.163 | 1.626 | 2.120 | 2.526 | 2.813 |
| 25000. | 0.356 | 0.728 | 1.131 | 1.584 | 2.075 | 2.490 | 2.782 |
| 25500. | 0.346 | 0.708 | 1.100 | 1.544 | 2.032 | 2.457 | 2.751 |
| 26000. | 0.336 | 0.690 | 1.072 | 1.508 | 1.990 | 2.424 | 2.719 |
| 26500. | 0.328 | 0.672 | 1.046 | 1.473 | 1.951 | 2.397 | 2.688 |
| 27000. | 0.319 | 0.654 | 1.019 | 1.437 | 1.912 | 2.361 | 2.656 |
| 27500. | 0.311 | 0.637 | 0.997 | 1.406 | 1.873 | 2.330 | 2.625 |
| 28000. | 0.304 | 0.623 | 0.974 | 1.376 | 1.837 | 2.299 | 2.593 |
| 28500. | 0.298 | 0.608 | 0.952 | 1.346 | 1.802 | 2.268 | 2.561 |
| 29000. | 0.292 | 0.596 | 0.934 | 1.318 | 1.768 | 2.237 | 2.528 |
| 29500. | 0.285 | 0.584 | 0.915 | 1.292 | 1.734 | 2.206 | 2.495 |
| 30000. | 0.279 | 0.572 | 0.897 | 1.267 | 1.704 | 2.174 | 2.461 |

CROSS CURVE OF STABILITY




GZ（作 画）

（15）

I N F L O W   A N G L E

UND. UPP. DECK

| | | | | | |
|---|---|---|---|---|---|
| INCLIN.ANGLE | 0 | 5 | 10 | 15 | 20 |
| DISP'T (MT) | 66177.50 | 66170.44 | 66176.37 | 64078.81 | 64557.16 |
| INCLIN.ANGLE | 25 | 30 | 35 | 40 | 45 |
| DISP'T (MT) | 61569.74 | 57738.21 | 53199.02 | 47940.11 | 42194.07 |
| INCLIN.ANGLE | 50 | 55 | 60 | 65 | 70 |
| DISP'T (MT) | 36836.00 | 31989.85 | 27714.17 | 23839.65 | 20290.76 |
| INCLIN.ANGLE | 75 | 80 | 85 | 90 | |
| DISP'T (MT) | 17007.75 | 14009.29 | 11228.92 | 8624.49 | |

** FOR REFERENCE **

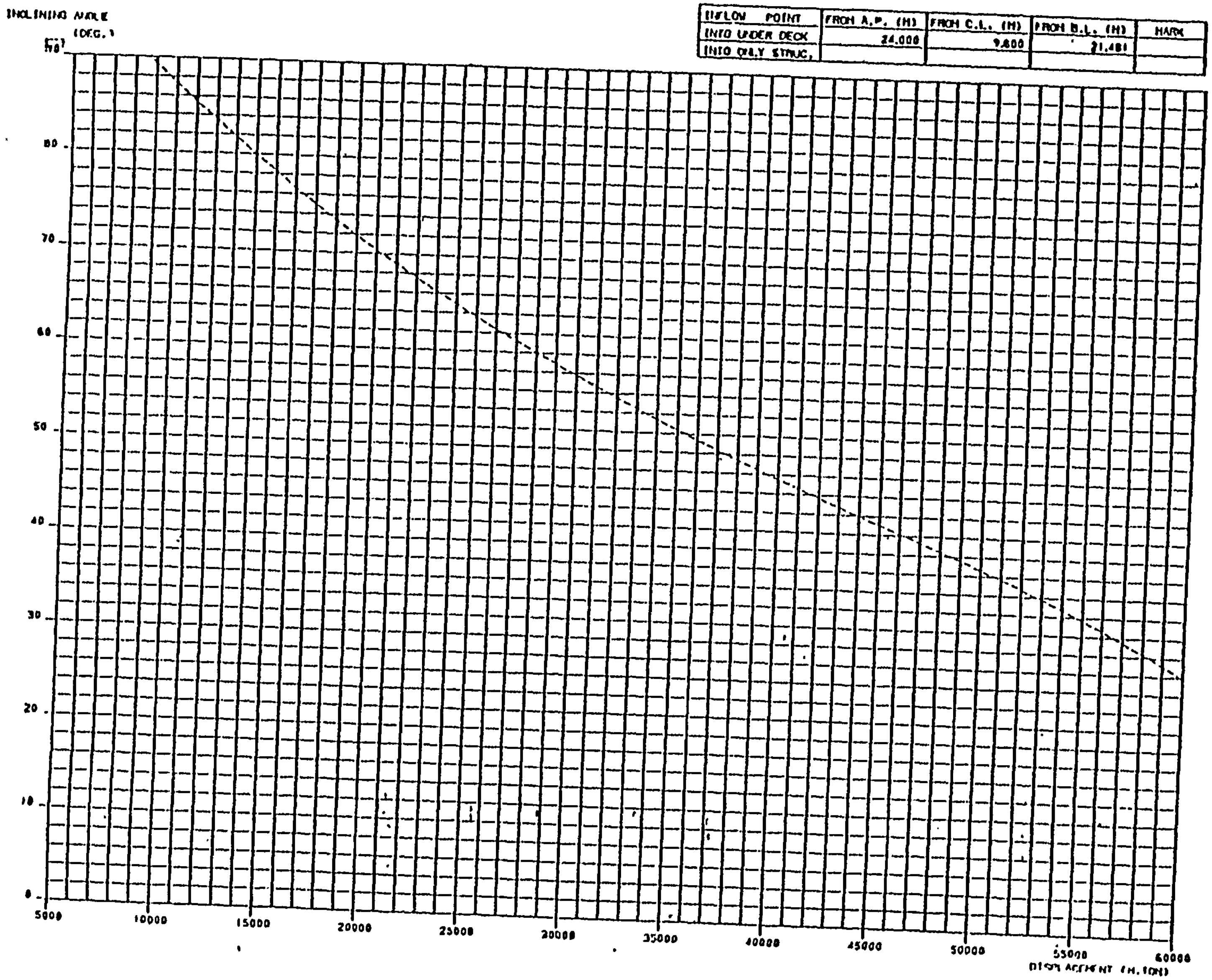
INFLOW ANGLE 43.89 DEG
AT DISP'T 43465.42 MT

INFLOW ANGLE POINT  X = 24.000 M FROM A.P.
Y = 9.600 M FROM C.L.
Z = 21.401 M FROM B.L.

海水流入角

## CURVE OF INFLOW ANGLE

| INFLOW POINT | FROM A.P. (M) | FROM C.L. (M) | FROM B.L. (M) | MARK |
|---|---|---|---|---|
| INTO UNDER DECK | 24.000 | 9.600 | 21.481 | |
| INTO ONLY STRUC. | | | | |




海水流入角

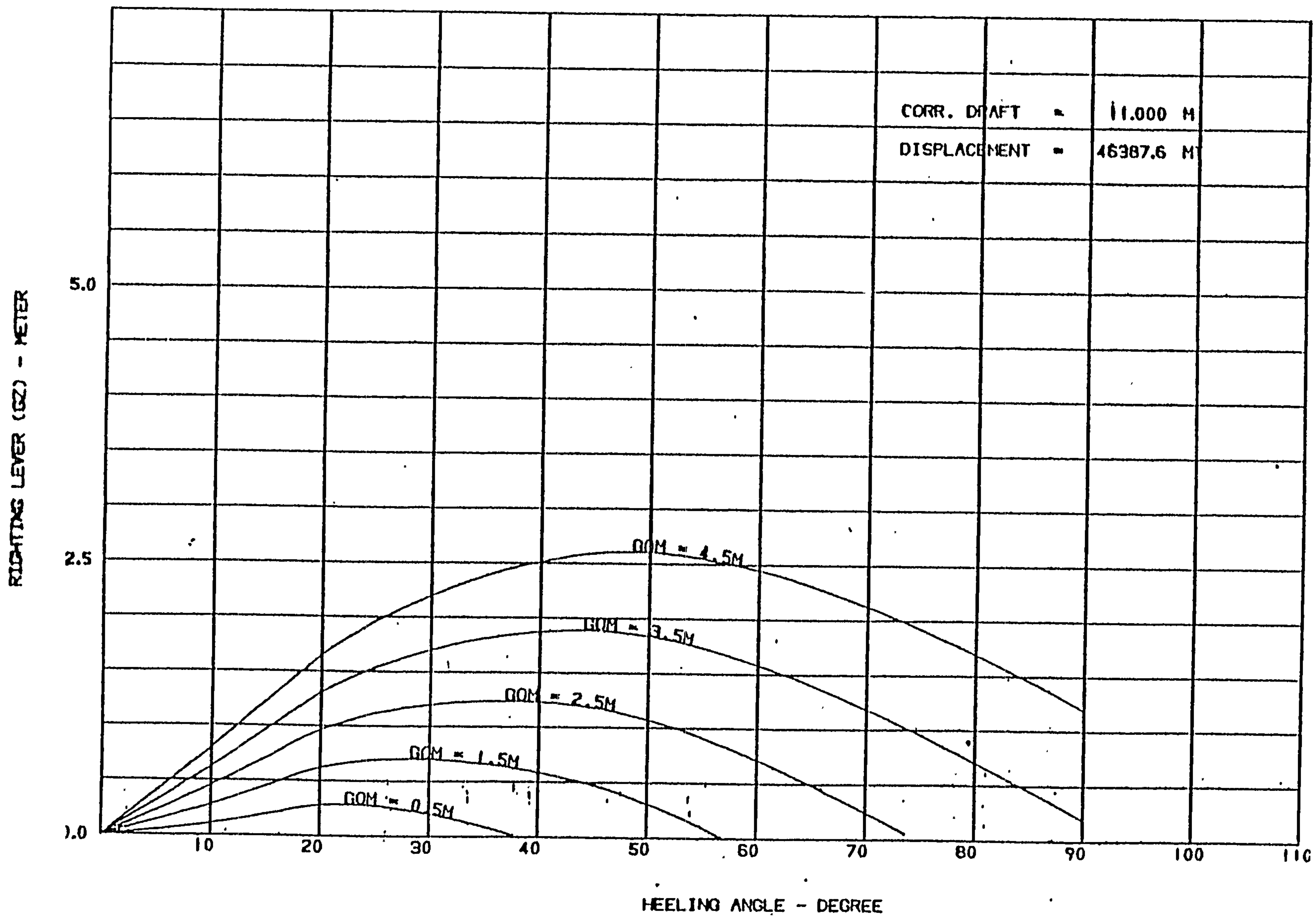
吃水別復元力曲線

RIGHTING LEVER (GZ) FOR OPERATIONAL INFORMATION (UNIT BY METRIC)

NO. 1 DRAFT = 10.000 M DISPLACEMENT = 195609.7 MT

INCLINING ANGLE (DEG.) 10 20 30 40 50 60 70 80 90 ← このOUTPUT角度は固定。

| GOM | GZ (10) | GZ (20) | GZ (30) | GZ (40) | GZ (50) | GZ (60) | GZ (70) | GZ (80) | GZ (90) |
|---|---|---|---|---|---|---|---|---|---|
| 8.000 | 1.473 | 2.913 | 2.547 | 1.020 | -1.669 | -5.051 | -8.665 | -12.216 | -15.432 |
| 10.000 | 1.820 | 3.597 | 3.547 | 2.305 | -0.137 | -3.319 | -6.786 | -10.246 | -13.435 |
| 12.000 | 2.167 | 4.281 | 4.547 | 3.591 | 1.395 | -1.587 | -4.906 | -8.276 | -11.438 |
| 14.000 | 2.514 | 4.965 | 5.547 | 4.876 | 2.927 | 0.145 | -3.027 | -6.307 | -9.441 |
| 16.000 | 2.862 | 5.649 | 6.547 | 6.162 | 4.459 | 1.877 | -1.147 | -4.337 | -7.442 |
| 18.000 | 3.209 | 6.333 | 7.547 | 7.448 | 5.991 | 3.609 | 0.732 | -2.368 | -5.443 |
| 20.000 | 3.556 | 7.017 | 8.547 | 8.733 | 7.523 | 5.341 | 2.611 | -0.398 | -3.445 |
| 22.000 | 3.904 | 7.701 | 9.547 | 10.019 | 9.055 | 7.073 | 4.491 | 1.572 | -1.444 |
| 24.000 | 4.251 | 8.385 | 10.547 | 11.304 | 10.587 | 8.805 | 6.370 | 3.541 | 0.558 |
| 26.000 | 4.598 | 9.069 | 11.547 | 12.590 | 12.119 | 10.537 | 8.249 | 5.511 | 2.561 |


CORR. DRAFT = 11.000 M
DISPLACEMENT = 46387.6 MT
GOM = 4.5M
GOM = 3.5M
GOM = 2.5M
GOM = 1.5M
GOM = 0.5M
5.0
2.5
0.0
10
20
30
40
50
60
70
80
90
100
110
RIGHTING LEVER (GZ) - METER
HEELING ANGLE - DEGREE

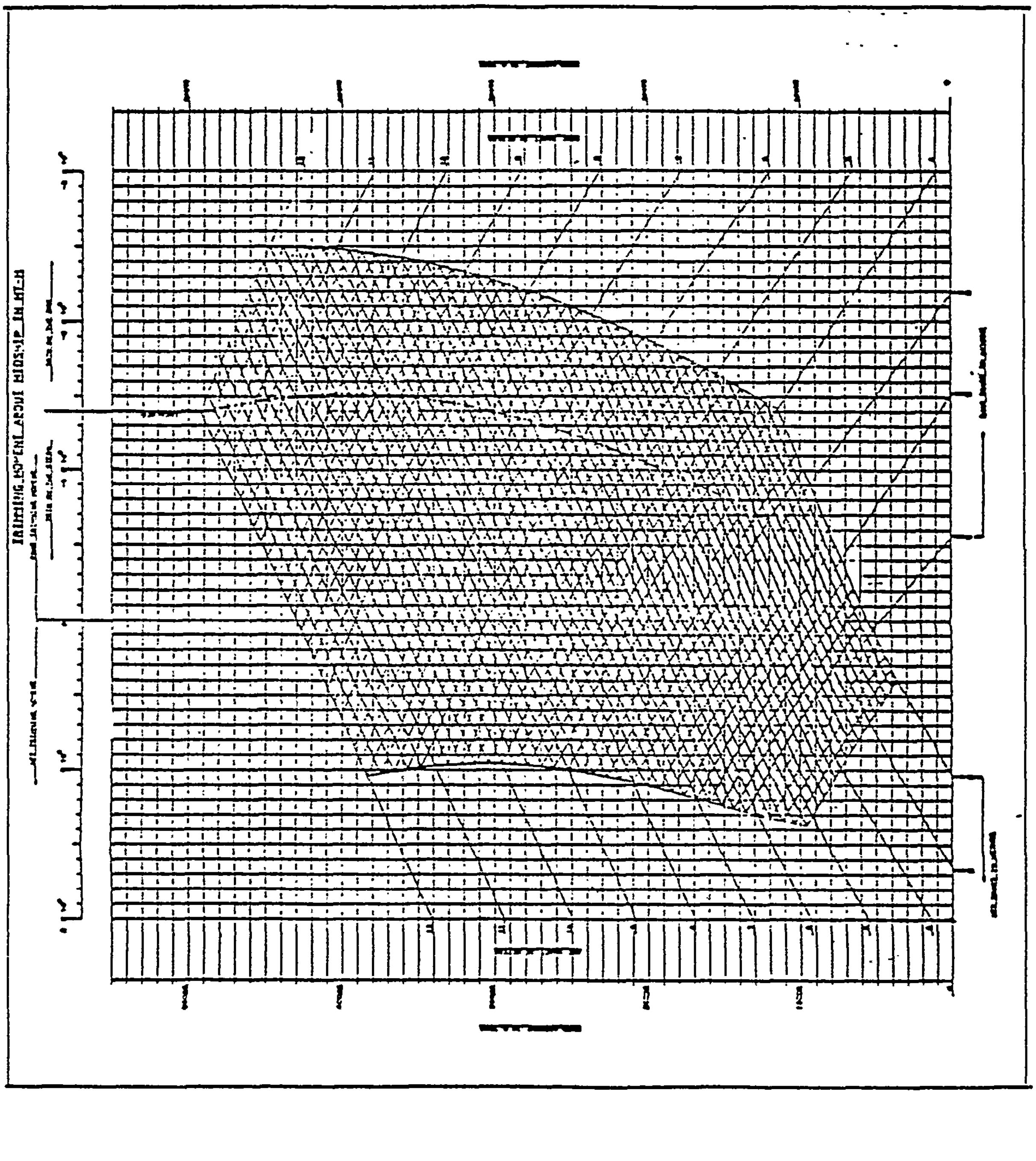
吃水別復元力曲線

トリム時排水量修正

## DISPLACEMENT CORRECTION TABLE DUE TO TRIM (MT)

| MEAN DRAFT (M) | TRIM (M) -0.50 | 0.0 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 |
|---|---|---|---|---|---|---|---|---|
| 3.00 | 617 | 0 | -602 | -1192 | -1772 | -2340 | -2900 | -3448 |
| 3.50 | 613 | 0 | -601 | -1192 | -1772 | -2343 | -2906 | -3459 |
| 4.00 | 610 | 0 | -599 | -1189 | -1769 | -2341 | -2905 | -3460 |
| 4.50 | 606 | 0 | -596 | -1183 | -1762 | -2333 | -2897 | -3452 |
| 5.00 | 602 | 0 | -592 | -1176 | -1752 | -2321 | -2882 | -3435 |
| 5.50 | 596 | 0 | -585 | -1165 | -1737 | -2302 | -2861 | -3413 |
| 6.00 | 589 | 0 | -580 | -1154 | -1721 | -2282 | -2839 | -3389 |
| 6.50 | 582 | 0 | -575 | -1144 | -1707 | -2265 | -2819 | -3366 |
| 7.00 | 576 | 0 | -569 | -1133 | -1692 | -2246 | -2796 | -3341 |
| 7.50 | 569 | 0 | -564 | -1122 | -1676 | -2226 | -2772 | -3313 |
| 8.00 | 563 | 0 | -558 | -1111 | -1660 | -2204 | -2743 | -3270 |
| 8.50 | 556 | 0 | -551 | -1097 | -1638 | -2175 | -2708 | -3236 |
| 9.00 | 549 | 0 | -540 | -1076 | -1609 | -2139 | -2668 | -3193 |
| 9.50 | 544 | 0 | -532 | -1060 | -1584 | -2117 | -2629 | -3140 |
| 10.00 | 540 | 0 | -525 | -1044 | -1561 | -2077 | -2591 | -3102 |
| 10.50 | 530 | 0 | -517 | -1028 | -1537 | -2044 | -2551 | -3054 |
| 11.00 | 521 | 0 | -508 | -1012 | -1512 | -2011 | -2509 | -3004 |
| 11.50 | 511 | 0 | -499 | -994 | -1485 | -1975 | -2464 | -2949 |
| 12.00 | 500 | 0 | -490 | -975 | -1456 | -1936 | -2414 | -2889 |
| 12.50 | 491 | 0 | -479 | -954 | -1425 | -1893 | -2360 | -2832 |
| 13.00 | 481 | 0 | -468 | -931 | -1390 | -1847 | -2300 | -2750 |
| 13.50 | 468 | 0 | -455 | -904 | -1349 | -1792 | -2233 | -2670 |
| 14.00 | 455 | 0 | -441 | -876 | -1307 | -1737 | -2164 | -2587 |
| 14.50 | 441 | 0 | -427 | -848 | -1265 | -1681 | -2094 | -2504 |
| 15.00 | 427 | 0 | -413 | -821 | -1224 | -1625 | -2024 | -2419 |
| 15.50 | 413 | 0 | -399 | -792 | -1181 | -1567 | -1951 | -2330 |
| 16.00 | 399 | 0 | -385 | -764 | -1137 | -1508 | -1875 | -2238 |
| 16.50 | 383 | 0 | -369 | -731 | -1080 | -1443 | -1794 | -2141 |
| 17.00 | 367 | 0 | -352 | -695 | -1030 | -1377 | -1712 | -2043 |
| 17.50 | 350 | 0 | -337 | -668 | -993 | -1315 | -1634 | -1949 |
| 18.00 | 333 | 0 | -322 | -638 | -948 | -1254 | -1557 | -1854 |
| 18.50 | 318 | 0 | -306 | -605 | -898 | -1188 | -1475 | -1755 |
| 19.00 | 303 | 0 | -289 | -571 | -848 | -1122 | -1391 | -1656 |
| 19.50 | 286 | 0 | -273 | -539 | -800 | -1057 | -1310 | -1559 |
| 20.00 | 269 | 0 | -257 | -507 | -751 | -992 | -1229 | -1461 |
| 20.50 | 253 | 0 | -241 | -475 | -703 | -928 | -1159 | -1366 |
| 21.00 | 236 | 0 | -228 | -443 | -655 | -864 | -1070 | -1271 |
| 21.50 | 221 | 0 | -209 | -411 | -608 | -801 | -990 | -1174 |
| 22.00 | 205 | 0 | -193 | -380 | -561 | -738 | -911 | -1079 |
| 22.50 | 191 | 0 | -178 | -349 | -514 | -676 | -834 | -987 |
| 23.00 | 177 | 0 | -163 | -319 | -469 | -616 | -760 | -900 |
| 23.50 | 166 | 0 | -152 | -295 | -432 | -567 | -699 | -825 |
| 24.00 | 155 | 0 | -141 | -274 | -401 | -524 | -644 | -750 |
| 24.50 | 146 | 0 | -132 | -257 | -373 | -487 | -595 | -697 |
| 25.00 | 137 | 0 | -124 | -240 | -349 | -452 | -548 | -639 |
| 25.50 | 128 | 0 | -114 | -220 | -319 | -412 | -500 | -582 |
| 26.00 | 118 | 0 | -103 | -199 | -284 | -377 | -453 | -527 |
| 26.50 | 109 | 0 | -95 | -182 | -263 | -338 | -411 | -470 |
| 27.00 | 99 | 0 | -87 | -166 | -240 | -308 | -373 | -433 |

トリム――排水量ダイヤグラム



FORE DRAFT CORRECTION TABLE FOR DRAFT MARK (UNIT IN C.M.)



| AFT DRAFT (M) | FORE DRAFT (M) 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 | 13.00 | 14.00 | 15.00 | 16.00 | 17.00 | 18.00 | 19.00 | 20.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.00 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** |
| 5.00 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** |
| 6.00 | -0.7 | -0.4 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** |
| 7.00 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** |
| 8.00 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** | ****** |
| 9.00 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** | ****** |
| 10.00 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** | ****** |
| 11.00 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** | ****** |
| 12.00 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** | ****** |
| 13.00 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** | ****** |
| 14.00 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 | ****** |
| 15.00 | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 | 1.2 |
| 16.00 | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.9 |
| 17.00 | ****** | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 | 0.7 |
| 18.00 | ****** | ****** | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 | 0.5 |
| 19.00 | ****** | ****** | ****** | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 | 0.2 |
| 20.00 | ****** | ****** | ****** | ****** | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 | 0.0 |
| 21.00 | ****** | ****** | ****** | ****** | ****** | ****** | -2.8 | -2.5 | -2.3 | -2.1 | -1.8 | -1.6 | -1.4 | -1.2 | -0.9 | -0.7 | -0.5 | -0.2 |
| 19.00 | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 | -0.7 | -0.4 | -0.2 | 0.0 | 0.2 |
| 20.00 | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 | -0.7 | -0.4 | -0.2 | 0.0 |
| 21.00 | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 | -0.7 | -0.4 | -0.2 |
| 22.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 | -0.7 | -0.4 |
| 23.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 | -0.7 |
| 24.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 | -0.9 |
| 25.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 | -1.1 |
| 26.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 | -1.3 |
| 27.00 | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | ****** | -2.7 | -2.4 | -2.2 | -2.0 | -1.8 | -1.6 |

前後部吃水修正表

*** RESULT OF SECTIONAL AREA DATA FOR FREE DRAFT ( CASE NO. 1 ) ***

** FOR ORD. DATA **

DRAFT DATA

| | (D-1) | (D-2) | (D-3) | (D-4) | (D-5) |
|---|---|---|---|---|---|
| DRAFT (M) | 6.500 | 9.500 | 0.0 | 0.0 | 0.0 |
| POS.(FROM AP)(M) | 0.0 | 178.000 | 0.0 | 0.0 | 0.0 |

| | DIST. (FROM AP) (M) | DRAFT (M) | SEC.AREA (BOTH S.) (SQ.M) | AREA RATIO (SA/AM) | GIRTH LENGTH (M) | | DIST. (FROM AP) (M) | DRAFT (M) | SEC.AREA (BOTH S.) (SQ.M) | AREA RATIO (SA/AM) | GIRTH LENGTH (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.131 | 6.570 | 0.0 | 0.0 | 0.0 | 31 | 167.176 | 9.318 | 125.345 | 0.50973 | 28.829 |
| 2 | 4.331 | 6.573 | 1.652 | 0.00672 | 14.116 | 32 | 169.340 | 9.354 | 106.643 | 0.43368 | 26.965 |
| 3 | 4.530 | 6.576 | 2.591 | 0.01054 | 14.135 | 33 | 171.505 | 9.391 | 86.738 | 0.35273 | 25.039 |
| 4 | 5.513 | 6.593 | 7.273 | 0.02958 | 14.274 | 34 | 173.669 | 9.427 | 65.728 | 0.26729 | 23.145 |
| 5 | 6.495 | 6.609 | 12.052 | 0.04901 | 14.492 | 35 | 175.835 | 9.464 | 45.608 | 0.18547 | 21.606 |
| 6 | 8.660 | 6.646 | 22.923 | 0.09322 | 15.251 | 36 | 176.859 | 9.481 | 37.732 | 0.15344 | 22.304 |
| 7 | 10.824 | 6.682 | 34.383 | 0.13982 | 16.685 | 37 | 177.883 | 9.498 | 30.485 | 0.12397 | 21.626 |
| 8 | 12.990 | 6.719 | 46.387 | 0.18864 | 18.364 | 38 | 178.000 | 9.500 | 29.697 | 0.12077 | 21.458 |
| 9 | 15.155 | 6.755 | 58.625 | 0.23841 | 20.115 | 39 | 178.117 | 9.502 | 28.890 | 0.11749 | 21.204 |
| 10 | 17.319 | 6.792 | 70.929 | 0.28844 | 21.877 | 40 | 179.100 | 9.519 | 22.753 | 0.09253 | 18.938 |
| 11 | 21.650 | 6.865 | 95.247 | 0.38733 | 25.294 | 41 | 180.200 | 9.537 | 17.245 | 0.07013 | 16.191 |
| 12 | 25.981 | 6.938 | 118.386 | 0.48143 | 28.431 | 42 | 181.300 | 9.556 | 10.878 | 0.04424 | 12.640 |
| 13 | 33.310 | 7.011 | 139.678 | 0.56802 | 31.215 | 43 | 182.400 | 9.574 | 2.121 | 0.00863 | 5.399 |
| 14 | 34.441 | 7.084 | 158.500 | 0.64456 | 33.634 | 44 | 182.515 | 9.576 | 1.207 | 0.00491 | 4.430 |
| 15 | 43.300 | 7.230 | 187.569 | 0.76277 | 37.526 | 45 | 182.630 | 9.578 | 0.0 | 0.0 | 0.0 |
| 16 | 51.960 | 7.376 | 204.539 | 0.83178 | 40.402 | | | | | | |
| 17 | 60.620 | 7.522 | 212.211 | 0.86298 | 42.174 | | | | | | |
| 18 | 69.279 | 7.668 | 216.573 | 0.88072 | 42.645 | | | | | | |
| 19 | 89.003 | 8.000 | 226.012 | 0.91911 | 43.310 | | | | | | |
| 20 | 106.800 | 8.300 | 234.532 | 0.95376 | 43.910 | | | | | | |
| 21 | 117.380 | 8.470 | 239.596 | 0.97435 | 44.266 | | | | | | |
| 22 | 126.040 | 8.624 | 243.604 | 0.99065 | 44.436 | | | | | | |
| 23 | 134.700 | 8.770 | 245.904 | 1.00000 | 43.796 | | | | | | |
| 24 | 143.359 | 8.916 | 240.737 | 0.97899 | 42.198 | | | | | | |
| 25 | 147.690 | 8.989 | 232.170 | 0.94395 | 40.877 | | | | | | |
| 26 | 152.019 | 9.062 | 218.406 | 0.88818 | 39.089 | | | | | | |
| 27 | 156.350 | 9.135 | 199.039 | 0.80942 | 36.772 | | | | | | |
| 28 | 160.680 | 9.208 | 173.735 | 0.70651 | 33.925 | | | | | | |
| 29 | 162.845 | 9.245 | 158.920 | 0.64627 | 32.321 | | | | | | |
| 30 | 165.009 | 9.281 | 142.770 | 0.58059 | 30.617 | | | | | | |

(EXT.)

任意(区画，吃水)排水量

*** RESULT OF HYDROSTATIC PROPERTIES FOR FREE DRAFT ( CASE NO. 1 ) ***

DRAFT DATA

| | | (D-1) | (D-2) | (D-3) | (D-4) | (D-5) |
|---|---|---|---|---|---|---|
| DRAFT | (M) | 6.500 | 9.500 | 0.0 | 0.0 | 0.0 |
| POS.(FROM AP)(M) | | 0.0 | 178.000 | 0.0 | 0.0 | 0.0 |

| DISPT (MT) | DISPT(MLD) (MT) | APPEN (MT) | T P C (MT) | L C B (M) | L C F (M) | T KM (M) | L KM (M) | M T C (MT-M) | T C B (M) | T C F (M) |
|---|---|---|---|---|---|---|---|---|---|---|
| 33183. | 33072. | 112. | 43.00 | -8.82 | -3.11 | 11.87 | 252.77 | 463.47 | 0.0 | 0.0 |

| D.CORR. (MT) | W S A (SQ.M) | A M (SQ.M) | A W (SQ.M) | K B (M) |
|---|---|---|---|---|
| 32.59 | 6524.9 | 204.5 | 4195.6 | 4.16 |

| C B | C P | C W | C M |
|---|---|---|---|
| 0.9847 | 0.8862 | 0.8300 | 1.1111 |

任意(区画, 吃水)排水量

FR DIST TABLE

| SEQ.NO | FR.NAME | FR.NO | FR.SPACE | DIST.(AP) | DIST.(MID) |
|---|---|---|---|---|---|
| 1 | FH | -8.000 | 0.0 | -4.800 | 91.400 |
| 2 | FG | -7.000 | 0.600 | -4.200 | 90.800 |
| 3 | FF | -6.000 | 0.600 | -3.600 | 90.200 |
| 4 | FE | -5.000 | 0.600 | -3.000 | 89.600 |
| 5 | FD | -4.000 | 0.600 | -2.400 | 89.000 |
| 6 | FC | -3.000 | 0.600 | -1.800 | 88.400 |
| 7 | FB | -2.000 | 0.600 | -1.200 | 87.800 |
| 8 | FA | -1.000 | 0.600 | -0.600 | 87.200 |
| 9 | F0 | 0.0 | 0.600 | 0.0 | 86.600 |
| 10 | F1 | 1.000 | 0.600 | 0.600 | 86.000 |
| 11 | F2 | 2.000 | 0.600 | 1.200 | 85.400 |
| 12 | F2-1/2 | 2.500 | 0.600 | 1.800 | 84.800 |
| 13 | F3 | 3.000 | 0.600 | 2.400 | 84.200 |
| 14 | F4 | 4.000 | 0.600 | 3.000 | 83.600 |
| 15 | F5 | 5.000 | 0.600 | 3.600 | 83.000 |
| 16 | F5-1/2 | 5.500 | 0.600 | 4.200 | 82.400 |
| 17 | F6 | 6.000 | 0.600 | 4.800 | 81.800 |
| 18 | F7 | 7.000 | 0.600 | 5.400 | 81.200 |
| 19 | F8 | 8.000 | 0.600 | 6.000 | 80.600 |
| 20 | F8-1/2 | 8.500 | 0.600 | 6.600 | 80.000 |
| 21 | F9 | 9.000 | 0.800 | 7.200 | 79.400 |
| 22 | F10 | 10.000 | 0.800 | 8.000 | 78.600 |
| 23 | F11 | 11.000 | 0.800 | 8.800 | 77.800 |
| 24 | F12 | 12.000 | 0.800 | 9.600 | 77.000 |
| 25 | F13 | 13.000 | 0.800 | 10.400 | 76.200 |
| 26 | F14 | 14.000 | 0.800 | 11.200 | 75.400 |
| 27 | F15 | 15.000 | 0.800 | 12.000 | 74.600 |
| 28 | F16 | 16.000 | 0.800 | 12.800 | 73.800 |
| 29 | F17 | 17.000 | 0.800 | 13.600 | 73.000 |
| 30 | F18 | 18.000 | 0.800 | 14.400 | 72.200 |
| 31 | F19 | 19.000 | 0.800 | 15.200 | 71.400 |
| 32 | F20 | 20.000 | 0.800 | 16.000 | 70.600 |
| 33 | F21 | 21.000 | 0.800 | 16.800 | 69.800 |
| 34 | F22 | 22.000 | 0.800 | 17.600 | 69.000 |
| 35 | F23 | 23.000 | 0.800 | 18.400 | 68.200 |
| 36 | F24 | 24.000 | 0.800 | 19.200 | 67.400 |
| 37 | F25 | 25.000 | 0.800 | 20.000 | 66.600 |
| 38 | F26 | 26.000 | 0.800 | 20.800 | 65.800 |
| 39 | F27 | 27.000 | 0.800 | 21.600 | 65.000 |
| 40 | F28 | 28.000 | 0.800 | 22.400 | 64.200 |
| 41 | F29 | 29.000 | 0.800 | 23.200 | 63.400 |
| 42 | F30 | 30.000 | 0.800 | 24.000 | 62.600 |
| 43 | F31 | 31.000 | 0.800 | 24.800 | 61.800 |
| 44 | F32 | 32.000 | 0.800 | 25.600 | 61.000 |
| 45 | F33 | 33.000 | 0.800 | 26.400 | 60.200 |
| 46 | F34 | 34.000 | 0.800 | 27.200 | 59.400 |
| 47 | F35 | 35.000 | 0.800 | 28.000 | 58.600 |
| 48 | F36 | 36.000 | 0.800 | 28.800 | 57.800 |
| 49 | F37 | 37.000 | 0.800 | 29.600 | 57.000 |
| 50 | F38 | 38.000 | 0.800 | 30.400 | 56.200 |

| FRAME NO. | 6.000 M W.L. | 7.000 M W.L. | 8.000 M W.L. | 9.000 M W.L. | 10.000 M W.L. | 11.000 M W.L. | 12.000 M W.L. | 13.000 M W.L. | 14.000 M W.L. | 15.000 M W.L. | 16.000 M W.L. | 17.000 M W.L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FH | | | | | | 1.086 | 2.394 | 3.456 | 4.330 | 5.055 | 5.664 | 5.664 |
| FG | | | | | | 1.469 | 2.718 | 3.773 | 4.653 | 5.393 | 6.012 | 6.012 |
| FF | | | | | 0.095 | 1.731 | 3.024 | 4.087 | 4.971 | 5.723 | 6.355 | 6.355 |
| FE | | | | | 0.442 | 2.053 | 3.337 | 4.399 | 5.286 | 6.048 | 6.693 | 6.693 |
| FD | | | | | 0.827 | 2.374 | 3.647 | 4.708 | 5.596 | 6.367 | 7.024 | 7.024 |
| FC | | | | | 1.180 | 2.692 | 3.958 | 5.014 | 5.905 | 6.680 | 7.346 | 7.346 |
| FB | | | | | 1.525 | 3.009 | 4.243 | 5.318 | 6.211 | 6.985 | 7.659 | 7.659 |
| FA | | | | | 1.849 | 3.326 | 4.565 | 5.616 | 6.509 | 7.284 | 7.942 | 7.942 |
| F0 | | | | 0.445 | 2.210 | 3.642 | 4.864 | 5.910 | 6.801 | 7.575 | 8.255 | 8.255 |
| F1 | | | | 0.819 | 2.547 | 3.954 | 5.161 | 6.199 | 7.089 | 7.861 | 8.541 | 8.541 |
| F2 | | | | 1.190 | 2.880 | 4.263 | 5.455 | 6.484 | 7.373 | 8.141 | 8.820 | 8.820 |
| F2-1/2 | | | | 1.558 | 3.239 | 4.569 | 5.746 | 6.765 | 7.652 | 8.416 | 9.091 | 9.091 |
| F3 | | | | 1.924 | 3.532 | 4.872 | 6.035 | 7.042 | 7.925 | 8.684 | 9.355 | 9.355 |
| F4 | | | 0.458 | 2.288 | 3.851 | 5.171 | 6.319 | 7.315 | 8.191 | 8.945 | 9.612 | 9.612 |
| F5 | | | 0.856 | 2.648 | 4.167 | 5.466 | 6.598 | 7.582 | 8.451 | 9.200 | 9.863 | 9.863 |
| F5-1/2 | | 0.221 | 1.254 | 3.002 | 4.481 | 5.757 | 6.871 | 7.844 | 8.704 | 9.447 | 10.107 | 10.107 |
| F6 | 0.348 | 0.613 | 1.659 | 3.351 | 4.796 | 6.045 | 7.139 | 8.100 | 8.950 | 9.688 | 10.346 | 10.346 |
| F7 | 0.666 | 1.003 | 2.060 | 3.695 | 5.108 | 6.329 | 7.402 | 8.353 | 9.190 | 9.921 | 10.579 | 10.579 |
| F8 | 0.984 | 1.389 | 2.455 | 4.034 | 5.415 | 6.608 | 7.660 | 8.594 | 9.424 | 10.148 | 10.803 | 10.803 |
| F8-1/2 | 1.304 | 1.771 | 2.844 | 4.368 | 5.717 | 6.883 | 7.914 | 8.834 | 9.651 | 10.368 | 11.019 | 11.019 |
| F9 | 1.626 | 2.149 | 3.228 | 4.697 | 6.015 | 7.154 | 8.164 | 9.068 | 9.873 | 10.580 | 11.228 | 11.228 |
| F10 | 2.056 | 2.646 | 3.729 | 5.127 | 6.403 | 7.508 | 8.489 | 9.372 | 10.158 | 10.853 | 11.493 | 11.493 |
| F11 | 2.485 | 3.135 | 4.216 | 5.549 | 6.780 | 7.852 | 8.805 | 9.664 | 10.430 | 11.115 | 11.746 | 11.746 |
| F12 | 2.913 | 3.617 | 4.691 | 5.963 | 7.147 | 8.186 | 9.113 | 9.945 | 10.691 | 11.366 | 11.985 | 11.985 |
| F13 | 3.339 | 4.087 | 5.151 | 6.365 | 7.504 | 8.510 | 9.411 | 10.217 | 10.942 | 11.604 | 12.209 | 12.209 |
| F14 | 3.765 | 4.546 | 5.597 | 6.757 | 7.849 | 8.825 | 9.698 | 10.480 | 11.185 | 11.830 | 12.415 | 12.415 |
| F15 | 4.189 | 4.993 | 6.029 | 7.137 | 8.185 | 9.130 | 9.976 | 10.734 | 11.418 | 12.044 | 12.606 | 12.606 |
| F16 | 4.606 | 5.430 | 6.447 | 7.507 | 8.513 | 9.426 | 10.244 | 10.978 | 11.643 | 12.246 | 12.783 | 12.783 |
| F17 | 5.022 | 5.855 | 6.849 | 7.869 | 8.835 | 9.714 | 10.503 | 11.213 | 11.863 | 12.435 | 12.945 | 12.945 |
| F18 | 5.431 | 6.269 | 7.239 | 8.219 | 9.147 | 9.992 | 10.753 | 11.438 | 12.070 | 12.613 | 13.095 | 13.095 |
| F19 | 5.835 | 6.672 | 7.616 | 8.559 | 9.449 | 10.260 | 10.992 | 11.652 | 12.262 | 12.779 | 13.232 | 13.232 |
| F20 | 6.231 | 7.065 | 7.981 | 8.887 | 9.740 | 10.518 | 11.222 | 11.856 | 12.440 | 12.933 | 13.358 | 13.358 |
| F21 | 6.622 | 7.447 | 8.333 | 9.205 | 10.021 | 10.767 | 11.441 | 12.050 | 12.602 | 13.076 | 13.472 | 13.472 |
| F22 | 7.005 | 7.818 | 8.673 | 9.511 | 10.291 | 11.005 | 11.650 | 12.233 | 12.752 | 13.205 | 13.572 | 13.572 |
| F23 | 7.378 | 8.178 | 9.002 | 9.805 | 10.551 | 11.233 | 11.849 | 12.406 | 12.896 | 13.323 | 13.662 | 13.662 |
| F24 | 7.743 | 8.525 | 9.320 | 10.088 | 10.800 | 11.450 | 12.038 | 12.568 | 13.031 | 13.433 | 13.744 | 13.744 |
| F25 | 8.100 | 8.862 | 9.626 | 10.359 | 11.038 | 11.657 | 12.217 | 12.720 | 13.157 | 13.534 | 13.819 | 13.819 |
| F26 | 8.448 | 9.187 | 9.920 | 10.619 | 11.265 | 11.854 | 12.385 | 12.861 | 13.275 | 13.627 | 13.886 | 13.886 |
| F27 | 8.788 | 9.501 | 10.203 | 10.869 | 11.482 | 12.040 | 12.543 | 12.992 | 13.384 | 13.711 | 13.946 | 13.946 |
| F28 | 9.114 | 9.804 | 10.473 | 11.105 | 11.686 | 12.214 | 12.690 | 13.113 | 13.479 | 13.781 | 13.994 | 13.994 |
| F29 | 9.429 | 10.096 | 10.734 | 11.332 | 11.882 | 12.380 | 12.829 | 13.226 | 13.568 | 13.844 | 14.037 | 14.037 |
| F30 | 9.733 | 10.377 | 10.984 | 11.549 | 12.068 | 12.538 | 12.960 | 13.332 | 13.649 | 13.902 | 14.075 | 14.075 |
| F31 | 10.028 | 10.650 | 11.223 | 11.757 | 12.245 | 12.687 | 13.083 | 13.430 | 13.724 | 13.954 | 14.108 | 14.108 |
| F32 | 10.312 | 10.907 | 11.452 | 11.956 | 12.413 | 12.828 | 13.199 | 13.528 | 13.793 | 14.001 | 14.135 | 14.135 |
| F33 | 10.587 | 11.154 | 11.669 | 12.141 | 12.570 | 12.958 | 13.304 | 13.604 | 13.851 | 14.039 | 14.156 | 14.156 |
| F34 | 10.852 | 11.391 | 11.876 | 12.317 | 12.718 | 13.079 | 13.401 | 13.678 | 13.902 | 14.070 | 14.167 | 14.167 |
| F35 | 11.106 | 11.616 | 12.073 | 12.485 | 12.858 | 13.194 | 13.492 | 13.747 | 13.949 | 14.097 | 14.178 | 14.178 |
| F36 | 11.349 | 11.832 | 12.260 | 12.644 | 12.990 | 13.301 | 13.577 | 13.810 | 13.991 | 14.122 | 14.188 | 14.188 |
| F37 | 11.580 | 12.037 | 12.438 | 12.795 | 13.115 | 13.402 | 13.655 | 13.868 | 14.030 | 14.143 | 14.195 | 14.195 |
| F38 | 11.800 | 12.231 | 12.606 | 12.936 | 13.231 | 13.496 | 13.727 | 13.928 | 14.063 | 14.160 | 14.200 | 14.200 |

FR OFFSETS

3 NO.3 CARGO HOLD (FR.104.00 ( 0.0 ) - FR.130.00 ( 0.0 ) ) TANK BOTTOM = 1.817 TANK TOP = 17.320

| DRAFT (M) | GROSS V. (CUB. M) | NET V. (CUB. M) | K B (M) | L C B (M) | L C F (M) | CL B (M) | CL F (M) | A W (SQ. M) | I N A (TRV.) | I N A (LONG.) | K.P. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.817 | 0.0 | 0.0 | 1.817 | 0.0 | -10.600 | 0.0 | 0.0 | 481.3 | 14785. | 25189. | 1 |
| 2.000 | 89.78 | 88.51 | 1.907 | -10.600 | -10.600 | 0.0 | 0.0 | 489.0 | 15506. | 25593. | 0 |
| 3.000 | 598.79 | 596.99 | 2.418 | -10.600 | -10.600 | 0.0 | 0.0 | 531.0 | 19861. | 27793. | 0 |
| 3.343 | 783.66 | 781.30 | 2.596 | -10.600 | -10.600 | 0.0 | 0.0 | 568.7 | 22442. | 32347. | 1 |
| 4.000 | 1166.47 | 1162.97 | 2.950 | -10.600 | -10.600 | 0.0 | 0.0 | 597.5 | 26076. | 33484. | 0 |
| 4.870 | 1702.88 | 1697.77 | 3.419 | -10.600 | -10.600 | 0.0 | 0.0 | 642.1 | 31656. | 37292. | 1 |
| 4.999 | 1715.73 | 1710.58 | 3.430 | -10.600 | -10.200 | 0.0 | 0.0 | 662.5 | 32750. | 40832. | 1 |
| 5.000 | 1708.07 | 1703.51 | 3.492 | -10.584 | -10.200 | 0.0 | 0.0 | 667.5 | 33501. | 41143. | 0 |
| 6.000 | 2479.21 | 2471.77 | 4.053 | -10.477 | -10.200 | 0.0 | 0.0 | 713.1 | 40953. | 43979. | 0 |
| 7.000 | 3215.17 | 3205.52 | 4.614 | -10.413 | -10.200 | 0.0 | 0.0 | 758.8 | 49209. | 46789. | 0 |
| 7.300 | 3444.85 | 3434.51 | 4.703 | -10.399 | -10.200 | 0.0 | 0.0 | 772.5 | 51921. | 47635. | 1 |
| 8.000 | 3985.59 | 3973.63 | 5.327 | -10.372 | -10.200 | 0.0 | 0.0 | 772.5 | 51921. | 47635. | 0 |
| 9.000 | 4759.06 | 4743.78 | 5.889 | -10.344 | -10.200 | 0.0 | 0.0 | 772.5 | 51921. | 47635. | 0 |
| 10.000 | 5530.54 | 5513.94 | 6.295 | -10.324 | -10.200 | 0.0 | 0.0 | 772.5 | 51921. | 47635. | 0 |
| 10.300 | 5762.28 | 5744.99 | 6.399 | -10.319 | -10.200 | 0.0 | 0.0 | 772.5 | 51921. | 47635. | 1 |
| 11.000 | 6280.09 | 6261.25 | 6.749 | -10.309 | -10.200 | 0.0 | 0.0 | 707.0 | 39808. | 43594. | 0 |
| 12.000 | 6940.35 | 6919.52 | 7.200 | -10.299 | -10.200 | 0.0 | 0.0 | 613.5 | 26009. | 37622. | 0 |
| 13.000 | 7507.09 | 7484.55 | 7.599 | -10.291 | -10.200 | 0.0 | 0.0 | 520.0 | 15836. | 32054. | 0 |
| 13.993 | 7973.94 | 7947.11 | 7.942 | -10.286 | -10.200 | 0.0 | 0.0 | 428.0 | 8834. | 26364. | 1 |
| 14.271 | 8074.87 | 8072.56 | 8.037 | -10.291 | -10.600 | 0.0 | 0.0 | 307.5 | 6957. | 22502. | 1 |
| 14.793 | 8314.52 | 8289.55 | 8.208 | -10.299 | -10.600 | 0.0 | 0.0 | 332.6 | 4401. | 19318. | 1 |
| 15.000 | 8369.30 | 8344.23 | 8.236 | -10.300 | -10.600 | 0.0 | 0.0 | 332.6 | 4401. | 19319. | 0 |
| 15.695 | 8580.63 | 8554.07 | 8.418 | -10.308 | -10.600 | 0.0 | 0.0 | 332.6 | 4401. | 19319. | 1 |
| 15.783 | 8606.99 | 8581.14 | 8.451 | -10.309 | -10.200 | 0.0 | 0.0 | 221.8 | 2934. | 5725. | 1 |
| 16.000 | 8655.11 | 8629.12 | 8.492 | -10.308 | -10.200 | 0.0 | 0.0 | 221.8 | 2934. | 5725. | 0 |
| 17.000 | 8876.07 | 8850.21 | 8.692 | -10.305 | -10.200 | 0.0 | 0.0 | 221.8 | 2934. | 5725. | 0 |
| 17.320 | 8947.04 | 8920.96 | 8.759 | -10.305 | -10.200 | 0.0 | 0.0 | 221.8 | 2934. | 5725. | 1 |

タンク容積

### *** COMPARTMENT SUMMARY TABLE FOR TANK/HOLD ***

| NO | TANK/HOLD NAME | PLACE | AFT. BHD. FRNO | DIFF. | FWD. BHD. FRNO | DIFF. | VOLUME (CUB.M) | L C G (M) | K G (M) | T.INERTIA (M4) | T C G (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | FRESH WATER TANK (P) | 3 | 11 | | 17 | | 106.92 | 87.160 | 16.995 | 150. | |
| 2 | FRESH WATER TANK (S) | 4 | 9 | | 17 | | 136.30 | 87.879 | 17.004 | 183. | |
| 3 | DRINK WATER TANK (P) | 3 | 9 | | 11 | | 29.54 | 90.407 | 17.035 | 32. | |
| 4 | NO.3 F.O.T. (P/S) | 2 | 147 | | 174 | | 903.86 | -32.300 | 2.156 | 5408. | |
| 5 | NO.5 F.O.T. (P/S) | 2 | 66 | | 93 | | 823.27 | 31.903 | 2.106 | 4616. | |
| 6 | NO.7 F.O.T. (P) | 3 | 20 | | 40 | | 96.65 | 68.908 | 1.11[illegible] | 240. | |
| 7 | NO.7 F.O.T. (S) | 4 | 26 | | 40 | | 104.90 | 72.838 | 1.075 | 249. | |
| 8 | NO.6 F.O.T. (P/S) | 2 | 42 | | 66 | | 90.69 | 52.900 | 0.997 | 22. | |
| 9 | NO.1 T.S.T. (P/S) | 2 | 202 | | 227 | | 346.45 | -73.535 | 16.972 | 621. | |
| 10 | NO.2 T.S.T. (P/S) | 2 | 175 | | 202 | | 592.05 | -54.641 | 16.607 | 1219. | |
| 11 | NO.3 T.S.T. (P/S) | 2 | 121 | | 175 | | 1191.93 | -22.300 | 16.595 | 2431. | |
| 12 | NO.4 T.S.T. (P/S) | 2 | 67 | | 121 | | 1191.88 | 26.099 | 16.595 | 2431. | |
| 13 | NO.5 T.S.T. (P/S) | 2 | 40 | | 67 | | 581.34 | 53.150 | 16.654 | 1232. | |
| 14 | NO.1 W.B.T. (P/S) | 2 | 201 | | 227 | | 565.21 | -74.287 | 1.882 | 3173. | |
| 15 | NO.2 W.B.T. (P/S) | 2 | 174 | | 201 | | 872.04 | -53.659 | 2.165 | 5109. | |
| 16 | NO.4 W.B.T. (P) | 3 | 93 | | 147 | | 1007.69 | 0.100 | 2.156 | 10974. | |
| 17 | NO.4 W.B.T. (S) | 4 | 93 | | 147 | | 1007.69 | 0.100 | 2.156 | 10974. | |
| 18 | NO.6 W.B.T. (P/S) | 2 | 40 | | 66 | | 547.63 | 53.463 | 2.782 | 1100. | |
| 19 | F.P.T | 1 | 224 | | 232 | | 2963.91 | -90.252 | 9.506 | 5594. | |
| 20 | A.P.T. | 1 | -5 | -0.308 | 9 | | 270.53 | 94.055 | 12.790 | 2254. | |
| 21 | NO.1 CARGO HOLD | 1 | 202 | | 227 | | 7067.02 | -74.991 | 10.613 | 36162. | |
| 22 | NO.2 CARGO HOLD | 1 | 175 | | 202 | | 9923.[illegible]9 | -54.775 | 10.157 | 59970. | |
| 23 | NO.3 CARGO HOLD | 1 | 148 | | 175 | | 9861.69 | -33.273 | 10.124 | 60095. | |
| 24 | NO.4 CARGO HOLD | 1 | 121 | | 148 | | 9941.45 | -11.637 | 10.121 | 60095. | |
| 25 | NO.5 CARGO HOLD | 1 | 94 | | 121 | | 9967.70 | 9.980 | 10.141 | 60095. | |
| 26 | NO.6 CARGO HOLD | 1 | 67 | | 94 | | 9841.78 | 31.770 | 10.172 | 60095. | |
| 27 | NO.7 CARGO HOLD | 1 | 40 | | 67 | | 9106.09 | 52.760 | 10.569 | 56087. | |
| 30 | BILGE TANK | 5 | 9 | | 10 | | 20.46 | 87.081 | 1.101 | 6. | |
| 31 | SEP. BILGE OIL TANK | 4 | 18 | | 26 | | 17.42 | 79.733 | 1.266 | 9. | |
| 32 | F. O. OVER FLOW TANK | 1 | 36 | | 40 | | 30.53 | 65.839 | 0.990 | 25. | |
| 33 | LUB. OIL SUMP TANK | 1 | 21 | | 20 | | 24.31 | 78.050 | 1.695 | 6. | |
| 34 | COOLING WATER TANK | 1 | 6 | | 9 | | 24.04 | 92.111 | 6.443 | 21. | |
| 40 | NO.3 C.H. (IN DECK) | 1 | 148 | | 175 | | 11331.96 | -33.100 | 10.765 | 60095. | |
| 41 | NO.3 C.H. (CHECK) | 1 | 148 | | 175 | | 8354.66 | -33.100 | 9.600 | 14400. | |
| 42 | FOR W.L. CHECK | 1 | 100 | | 110 | | 2519.79 | 12.100 | 11.294 | 5333. | |

# タ ン ク 容 積

## TANK CAPACITY CURVES

MAX.Va. -1596.000 $M^3$

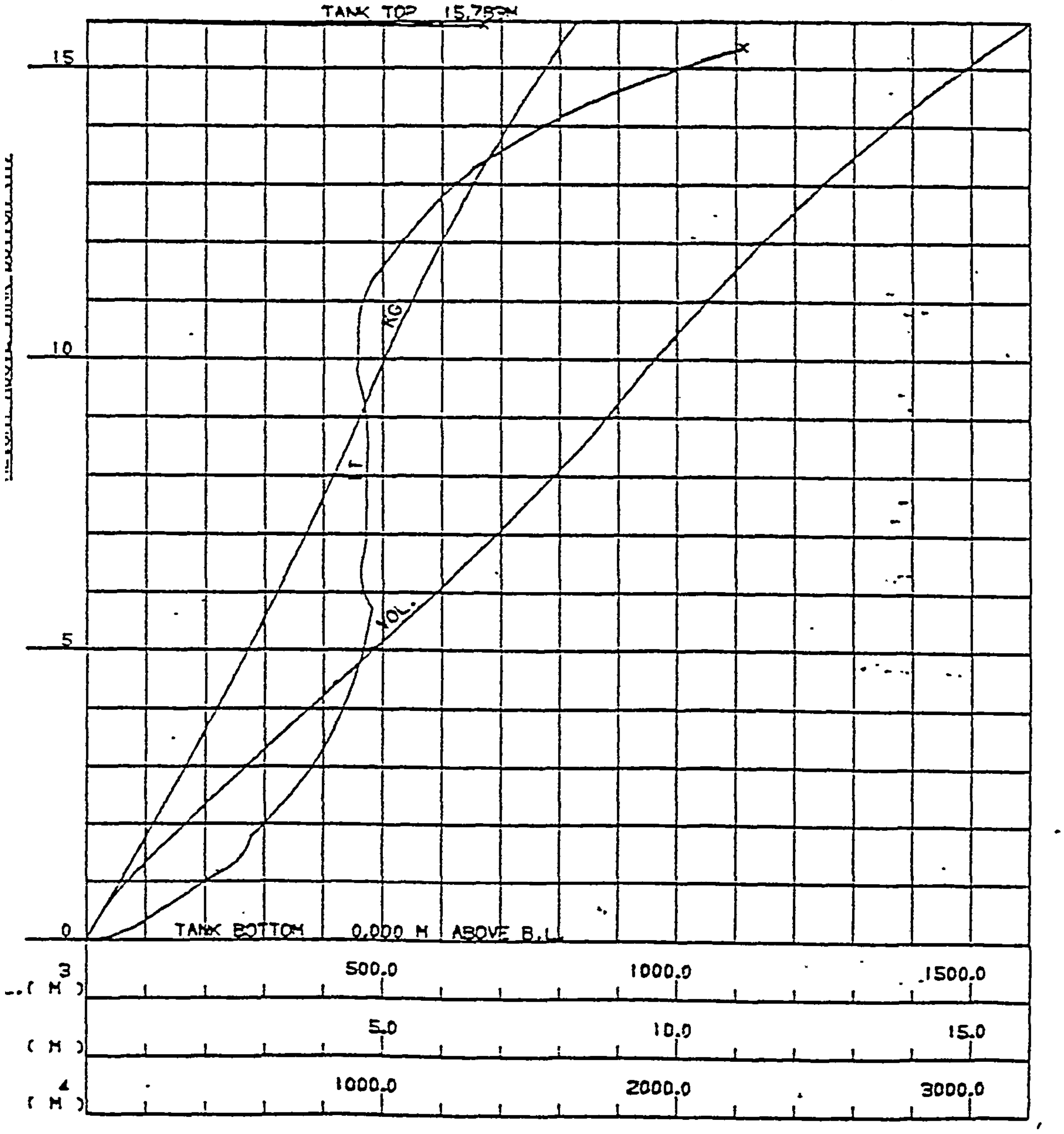
**FORE PEAK TANK**

MAX.KG 8-260 M

MAX.IT .2658330 M'

**FROM FR. 207.0 TO FR. 215-0**

LCG -.62331 M



** TANK CAPACITY DETAIL PRO. TABLE TYPE DATA PRINT **

TABLE TYPE NO.( 2)

UNIT SIGN ( 0) 0 : METRIC 1 : FEET

CAL. SIGN ( 0) 0 : INNAGE 1 : ULLAGE

ITEM DATA NO. ( 3)

INTERVAL DEPTH ( 1.0000)

| O/P UNIT | UNIT | | EXCHANGE RATES |
|---|---|---|---|
| 1 | 1 | CUB.M | 1.00000 |
| 5 | 1 | M.TON | 0.95000 |
| 3 | 1 | U.S.GAL | 6.28981 |

REMARK : S.G. = 0.950 MT/CUB.M

** TANK NAME DATA **

NO.1 FUEL OIL TANK (P/S)

** SOUNDING TUBE DATA **

| (S) SIDE DATA | | | CHENGE INTERVAL | | (P) SIDE DATA | | | CIENGE INTERVAL | |
|---|---|---|---|---|---|---|---|---|---|
| X | Y | Z | | | X | Y | Z | | |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.450 | 4.400 | 0.014 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.450 | 4.400 | 15.759 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |
| 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | | |

NO.2 FUEL OIL TANK (P/S)

| SOUND. (M) | CUB.M | M.TON | U.S.BBL | SOUND. (M) | CUB.M | M.TON | U.S.BBL | TANK NO.(19) | |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 4.1 | 3.9 | 25.8 | 0.50 | 158.1 | 150.2 | 994.4 | 4.08 | 3.17 |
| 0.01 | 7.0 | 6.6 | 43.9 | 0.51 | 161.3 | 153.2 | 1014.4 | 2.91 | 3.17 |
| 0.02 | 9.9 | 9.4 | 62.4 | 0.52 | 164.5 | 156.2 | 1034.4 | 2.94 | 3.18 |
| 0.03 | 12.9 | 12.2 | 80.9 | 0.53 | 167.6 | 159.3 | 1054.4 | 2.94 | 3.18 |
| 0.04 | 15.8 | 15.0 | 99.5 | 0.54 | 170.9 | 162.3 | 1074.4 | 2.95 | 3.18 |
| 0.05 | 18.9 | 17.9 | 118.2 | 0.55 | 174.0 | 165.3 | 1094.5 | 2.98 | 3.18 |
| 0.06 | 21.8 | 20.7 | 136.9 | 0.56 | 177.2 | 168.3 | 1114.5 | 2.98 | 3.18 |
| 0.07 | 24.8 | 23.5 | 155.8 | 0.57 | 180.4 | 171.4 | 1134.6 | 3.00 | 3.19 |
| 0.08 | 27.8 | 26.4 | 174.7 | 0.58 | 183.6 | 174.4 | 1154.7 | 3.00 | 3.20 |
| 0.09 | 30.8 | 29.2 | 193.6 | 0.59 | 186.8 | 177.4 | 1174.9 | 3.01 | 3.20 |
| 0.10 | 33.8 | 32.1 | 212.6 | 0.60 | 190.0 | 180.5 | 1194.9 | 3.01 | 3.20 |
| 0.11 | 36.8 | 35.0 | 231.6 | 0.61 | 193.2 | 183.5 | 1215.0 | 3.01 | 3.20 |
| 0.12 | 39.8 | 37.9 | 250.6 | 0.62 | 196.4 | 186.5 | 1235.0 | 3.03 | 3.20 |
| 0.13 | 42.8 | 40.7 | 269.7 | 0.63 | 199.6 | 189.6 | 1255.2 | 3.03 | 3.21 |
| 0.14 | 45.9 | 43.6 | 288.9 | 0.64 | 202.9 | 192.6 | 1275.4 | 3.04 | 3.21 |
| 0.15 | 49.0 | 46.5 | 307.9 | 0.65 | 206.0 | 195.7 | 1295.5 | 3.05 | 3.21 |
| 0.16 | [illegible] | 49.4 | 327.1 | 0.66 | 209.2 | 198.7 | 1315.7 | 3.05 | 3.21 |
| 0.17 | 55.1 | 52.3 | 346.3 | 0.67 | 212.4 | 201.8 | 1335.9 | 3.06 | 3.21 |
| 0.18 | 58.1 | 55.2 | 365.6 | 0.68 | 215.6 | 204.8 | 1356.0 | 3.06 | 3.21 |
| 0.19 | 61.2 | 58.1 | 384.9 | 0.69 | 218.8 | 207.9 | 1376.2 | 3.06 | 3.21 |
| 0.20 | 64.3 | 61.0 | 404.2 | 0.70 | 222.0 | 210.9 | 1396.4 | 3.07 | 3.21 |
| 0.21 | 67.3 | 64.0 | 423.5 | 0.71 | 225.2 | 214.0 | 1416.5 | 3.08 | 3.21 |
| 0.22 | 70.4 | 66.9 | 442.9 | 0.72 | 228.4 | 217.0 | 1436.7 | 3.08 | 3.21 |
| 0.23 | 73.5 | 69.8 | 462.3 | 0.73 | 231.6 | 220.0 | 1456.9 | 3.08 | 3.21 |
| 0.24 | 76.6 | 72.8 | 481.7 | 0.74 | 234.8 | 223.1 | 1477.1 | 3.09 | 3.21 |
| 0.25 | 79.7 | 75.7 | 501.2 | 0.75 | 238.0 | 226.1 | 1497.3 | 3.10 | 3.22 |
| 0.26 | 82.8 | 78.6 | 520.7 | 0.76 | 241.3 | 229.2 | 1517.5 | 3.10 | 3.22 |
| 0.27 | 85.9 | 81.6 | 540.2 | 0.77 | 244.5 | 232.3 | 1537.8 | 3.10 | 3.22 |
| 0.28 | 89.0 | 84.5 | 559.8 | 0.78 | 247.7 | 235.3 | 1559.0 | 3.10 | 3.22 |
| 0.29 | 92.1 | 87.5 | 579.2 | 0.79 | 250.9 | 238.4 | 1578.2 | 3.10 | 3.22 |
| 0.30 | 95.2 | 90.4 | 599.0 | 0.80 | 254.1 | 241.4 | 1598.5 | 3.12 | 3.22 |
| 0.31 | 98.3 | 93.4 | 618.6 | 0.81 | 257.4 | 244.5 | 1618.7 | 3.12 | 3.22 |
| 0.32 | 101.4 | 96.4 | 639.0 | 0.82 | 260.6 | 247.6 | 1639.0 | 3.12 | 3.22 |
| 0.33 | 104.6 | 99.3 | 657.6 | 0.83 | 263.8 | 250.6 | 1659.3 | 3.13 | 3.22 |
| 0.34 | 107.7 | 102.3 | 677.3 | 0.84 | 267.0 | 253.7 | 1679.5 | 3.13 | 3.22 |
| 0.35 | 110.8 | 105.3 | 697.0 | 0.85 | 270.2 | 256.7 | 1679.8 | 3.13 | 3.23 |
| 0.36 | 113.9 | 108.2 | 716.6 | 0.86 | 273.5 | 259.8 | 1720.1 | 3.13 | 3.23 |
| 0.37 | 117.1 | 111.2 | 735.4 | 0.87 | 276.7 | 262.9 | 1740.4 | 3.14 | 3.23 |
| 0.38 | 120.2 | 114.2 | 756.2 | 0.88 | 279.9 | 265.9 | 1760.7 | 3.14 | 3.23 |
| 0.39 | 123.4 | 117.2 | 775.9 | 0.89 | 283.2 | 269.0 | 1781.0 | 3.14 | 3.23 |
| 0.40 | 126.5 | 120.2 | 795.7 | 0.90 | 286.4 | 272.1 | 1801.3 | 3.14 | 3.23 |
| 0.41 | 129.6 | 123.2 | 815.5 | 0.91 | 289.6 | 275.1 | 1821.6 | 3.14 | 3.23 |
| 0.42 | 132.8 | 126.2 | 835.4 | 0.92 | 292.8 | 278.2 | 1841.9 | 3.16 | 3.23 |
| 0.43 | 136.0 | 129.2 | 855.2 | 0.93 | 296.1 | 281.3 | 1862.2 | 3.16 | 3.23 |
| 0.44 | 139.1 | 132.2 | 875.0 | 0.94 | 299.3 | 284.3 | 1882.5 | 3.16 | 3.23 |
| 0.45 | 142.3 | 135.2 | 894.9 | 0.95 | 302.5 | 287.4 | 1902.8 | 3.16 | 3.23 |
| 0.46 | 145.4 | 138.2 | 914.8 | 0.96 | 305.7 | 290.5 | 1923.1 | 3.16 | 3.23 |
| 0.47 | 148.6 | 141.2 | 934.7 | 0.97 | 309.0 | 293.5 | 1943.4 | 3.16 | 3.23 |
| 0.48 | 151.8 | 144.2 | 954.5 | 0.98 | 312.2 | 296.6 | 1963.7 | 3.16 | 3.23 |
| 0.49 | 154.9 | 147.2 | 974.4 | 0.99 | 315.4 | 299.7 | 1984.0 | 3.17 | 3.23 |

S.G. = 0.950 MT/CUB.M
FULL VOLUME ( 763.78 CUB.M ) AT FULL SOUND. ( 5.986 M )

タンク容量表

##### USING DATA CHECK PRINT BY TANK NO 67 #####

TRIM/HEEL CHECK TANK

INDICATION OF CALCULATION AND PRINT OUT

PRINT FORMAT 29 (USING UNDER DATA)

| | | | | | |
|---|---|---|---|---|---|
| TRIM DATA | -1.000 | 0.0 | 1.000 | 1.500 | 2.000 |
| | 2.500 | 3.000 | 3.500 | 4.000 | |
| HEEL DATA | -2.000 | -1.500 | -1.000 | -0.500 | 0.0 |
| | 0.500 | 1.000 | 1.500 | 2.000 | |
| DRAFT DATA | 1.000 | 1.500 | 2.000 | 2.500 | 3.000 |
| | 3.500 | 4.000 | 4.500 | 5.000 | 5.500 |
| | 6.000 | 7.000 | 8.000 | 9.000 | 10.000 |
| | 11.000 | 12.000 | 0.0 | 0.0 | 0.0 |

| | | | |
|---|---|---|---|
| AMENDMENT VALUE | 0 | INDICATION OF SCALE | |
| INDICATION OF TUBE | 0 | SOUNDING | |
| TANK ARRANGE | 1 | P/S OR C | |
| EXCHANGE RATE | 0.0 | | |

##### TUBE DATA #####

| X-COOD S | X-COOD P | Y-COOD S | Y-COOD P | Z-COOD S | Z-COOD P |
|---|---|---|---|---|---|
| 0.0 | 1.000 | 0.0 | 4.000 | 0.0 | 0.0 |
| 0.0 | 1.000 | 0.0 | 4.000 | 0.0 | 3.000 |
| 0.0 | 1.000 | 0.0 | 4.000 | 0.0 | 13.000 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

タンク TRIM/HEEL 修正表

タンク TRIM/HEEL 修正表

TRIM/HEEL CHECK TANK

CORRECTION TABLE DUE TO TRIM (UNIT : CM)

| SOUND. (M) | TRIM (M) BY BOW -1.00 | 0.0 | 1.00 | 1.50 | BY STERN 2.00 | 2.50 | 3.00 | 3.50 | 4.00 |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 1.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 2.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 2.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 3.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 3.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 4.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 4.500 | 1. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 5.000 | -1. | 0. | -2. | -4. | -5. | -6. | -7. | -8. | -9. |
| 5.500 | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. |
| 6.000 | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. |
| 7.000 | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. |
| 8.000 | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. |
| 9.000 | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. |
| 10.000 | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. |
| 11.000 | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. |
| 12.000 | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. |

CORRECTION TABLE DUE TO HEEL (UNIT : CM)

| SOUND. (M) | HEEL (DEG.) PORT -2.00 | -1.50 | -1.00 | -0.50 | 0.0 | STARB. 0.50 | 1.00 | 1.50 | 2.00 |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 1.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 2.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 2.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 3.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 3.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 4.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 4.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 5.000 | -1. | -1. | -1. | -1. | 0. | -4. | -8. | -11. | -15. |
| 5.500 | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. |
| 6.000 | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. |
| 7.000 | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. |
| 8.000 | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. |
| 9.000 | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. |
| 10.000 | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. |
| 11.000 | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. |
| 12.000 | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. |

TRIM/HEEL CHECK TANK

CORRECTION TABLE DUE TO TRIM (UNIT : CM)

| SOUND. (M) | BY BOW -1.00 | 0.0 | 1.00 | 1.50 | BY STERN 2.00 | 2.50 | 3.00 | 3.50 | 4.00 |
|---|---|---|---|---|---|---|---|---|---|
| | TRIM (M) | | | | | | | | |
| 1.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 1.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 2.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 2.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 3.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 3.500 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 4.000 | 2. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 4.500 | 1. | 0. | -2. | -3. | -4. | -6. | -7. | -8. | -9. |
| 5.000 | -1. | 0. | -2. | -4. | -5. | -6. | -7. | -8. | -9. |
| 5.500 | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. |
| 6.000 | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. |
| 7.000 | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. |
| 8.000 | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. |
| 9.000 | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. |
| 10.000 | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. |
| 11.000 | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. |
| 12.000 | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. |

CORRECTION TABLE DUE TO HEEL (UNIT : CM)

| SOUND. (M) | PORT -2.00 | -1.50 | -1.00 | -0.50 | 0.0 | 0.50 | STARB. 1.00 | 1.50 | 2.00 |
|---|---|---|---|---|---|---|---|---|---|
| | HEEL (DEG.) | | | | | | | | |
| 1.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 1.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 2.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 2.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 3.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 3.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 4.000 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 4.500 | 14. | 10. | 7. | 3. | 0. | -3. | -7. | -10. | -14. |
| 5.000 | -1. | -1. | -1. | -1. | 0. | -4. | -8. | -11. | -15. |
| 5.500 | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. | -50. |
| 6.000 | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. | -100. |
| 7.000 | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. | -200. |
| 8.000 | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. | -300. |
| 9.000 | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. | -400. |
| 10.000 | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. | -500. |
| 11.000 | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. | -600. |
| 12.000 | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. | -700. |

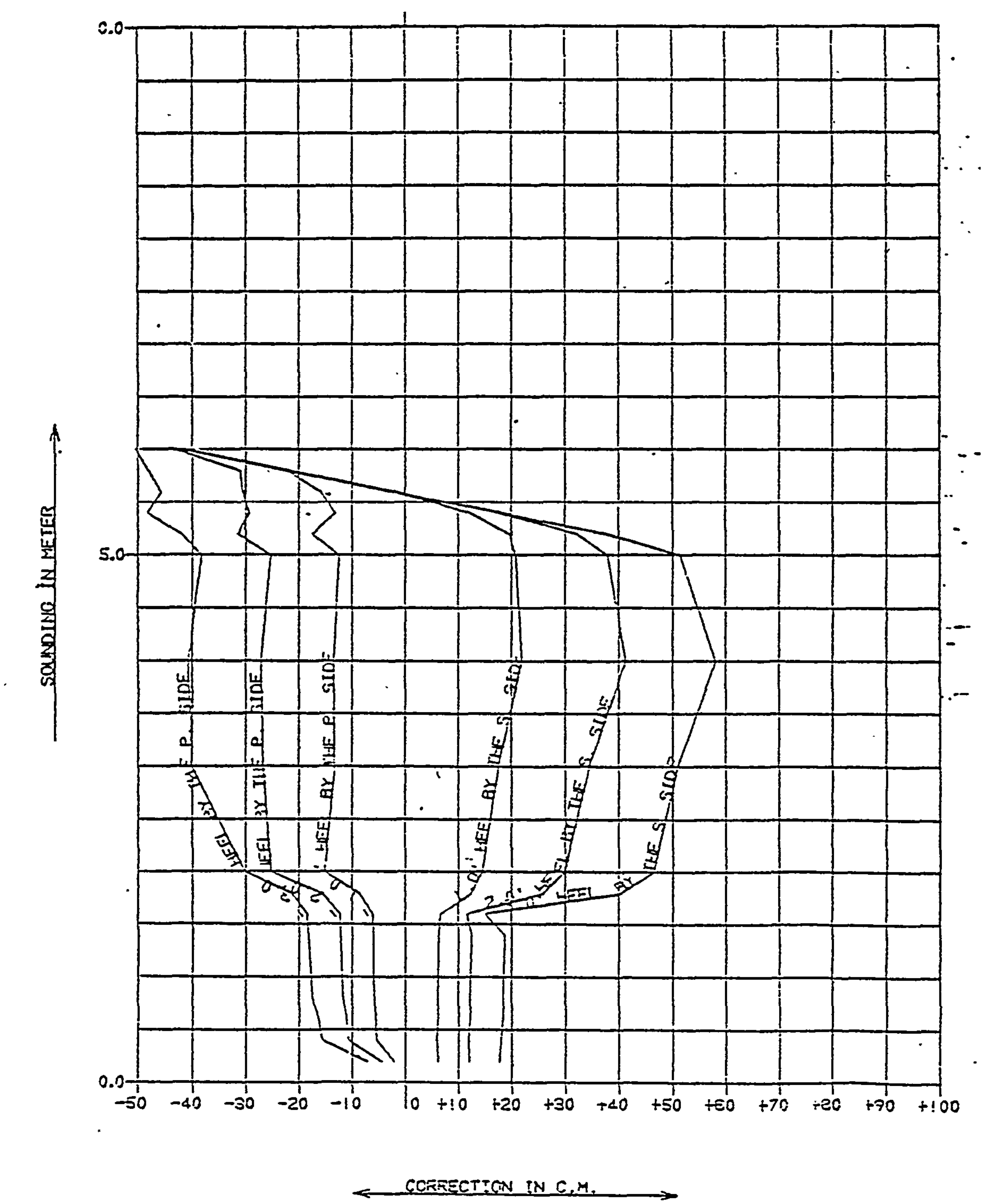
タンク TRIM/HEEL 修正表

# タンク TRIM/HEEL 修正表

NO.2 F. o. T. (P/S)
N0.4 F. o. T. (P/S)
NO.1 W. 6. T. (P/S)

SOUNDING

CORRECTION FOR HEEL



** IN PUT DATA ( PARTICULAR ) ** GRAIN HEELING MOMENT CALCULATION

UNIT OF OUT PUT : 0 0:METRIC 1:FEET

SIGN OF GRAIN LEVEL : 2 1:ULLAGE 2:SOUNDING 3:H.L. FROM B.L.

GRAIN RULE IMCO.A.I 264

SIGN OF CALC. (TRAN.) : 1 0:NOT CALC. 1:CALC. AND SEC.AREA PRINT 2:CALC.

(VERT.) : 1

SIGN OF VOID : 0 0:TRIMMING 1:SELF-TRIMMING 2:VOID DEPH

HEEL ANGLE OF GRAIN :
( FILLED) : 15.0 DEG.

(PARTLY FILLED) : 25.0 DEG.

HOLD NO. FOR HEELING MT. CALCULATION

12 23 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

** IN PUT DATA ( HATCH AND HATCH COVER ) **

| HATCH TYPE NO. | HATCH BREADTH AFT (M) | HATCH BREADTH FORE (M) | COAMING LENGTH (M) | HEIGHT AT C.L. (M) | DISTANCE FROM C.L. (M) | HATCH COVER HEIGHT SIDE (M) | HATCH COVER HEIGHT CENTER (M) |
|---|---|---|---|---|---|---|---|
| 1 | 14.400 | 14.400 | 12.000 | 1.312 | 0.0 | 0.704 | 0.704 |
| 2 | 14.400 | 14.400 | 11.200 | 1.312 | 0.0 | 0.661 | 0.661 |
| 1 | 0.800 | 0.800 | 0.800 | 1.000 | 11.400 | 0.0 | 0.0 |

MAX. 10

** IN PUT DATA ( FEEDER HOLE ) **

| FEEDER TYPE NO. | BREADTH (M) | LENGTH (M) | DISTANCE FROM C.L. (M) |
|---|---|---|---|
| 31 | 14.400 | 12.000 | 0.0 |
| 32 | 14.400 | 11.200 | 0.0 |
| 33 | 0.000 | 0.000 | 11.400 |

MAX. 10

GRAIN HEELING MT.

** IN PUT DATA (DECK , POSITION OF GIRDER AND VOID DEPTH) **

DECK NO. 1 (RSI3BOM [illegible])

| | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF. FROM AFT END. (M) | 4.800 | | | 16.100 | | | 0.0 | | | 0.0 | | | 0.0 | | | | |
| | 1 | 0.0 | | 1 | 0.0 | | 1 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.728 | 2 | | 0.150 | 2 | | 0.728 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 1 | 7.200 | | 1 | 7.200 | | 1 | 7.200 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 1 | | 0.0 | 1 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |

DIVA (A)

DECK NO. [illegible]

| | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF. FROM AFT END. (M) | [illegible] | | | 16.000 | | | 0.0 | | | 0.0 | | | 0.0 | | | | |
| | 1 | 0.0 | | 1 | 0.0 | | 1 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.728 | 2 | | 0.150 | 2 | | 0.728 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 1 | 7.200 | | 1 | 7.200 | | 1 | 7.200 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 1 | | 0.0 | 1 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |

DECK NO. 3

| | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) | TRANS. NO. | LONG. NO. | FROM CL (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF. FROM AFT END. (M) | 4.800 | | | 16.000 | | | 0.0 | | | 0.0 | | | 0.0 | | | | |
| | 3 | 0.0 | | 3 | 0.0 | | 3 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.728 | 3 | | 0.150 | 3 | | 0.728 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 3 | 7.200 | | 3 | 7.200 | | 3 | 7.200 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 3 | | 0.0 | 3 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |
| | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 |
| VOID DEP. | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 | 0 | | 0.0 |

(DECK (III) 1~9)

GRAIN HEELING MT.

***** GRAIN NO. 23 SECTIONAL AREA *****

(SEC. # 7-9)

SECTION AT FR.158.000 DIFFERENCE 0.0 M

| EVEN W.L. ABOVE BL (M) | SEC.AREA (SQ.M) | CL MT (SQ.M *M) EVEN W.L. | KG MT (SQ.M *M) EVEN W.L. | HEEL.HT OF SEC.AREA KP (SQ.M *M) HEEL.ANGLE 25.0 DEG. (TRAN.) | (VERT.) | | CL MT (SQ.M *M) HEEL W.L. | KG MT (SQ.M *M) HEEL W.L. | HEEL W.L. ABOVE BL AT CL (M) |
|---|---|---|---|---|---|---|---|---|---|
| 1.995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | -3.601 |
| 2.500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |
| 3.000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |
| 3.240 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | -3.601 |
| 3.500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |
| 4.000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |
| 4.305 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | -3.601 |
| 5.000 | 14.68 | 0.0 | 69.6 | -100.6 | 17.1 | 0 | -100.6 | 86.8 | 0.991 |
| 5.500 | 27.34 | 0.0 | 146.6 | -349.7 | 40.9 | 0 | -349.7 | 187.5 | 2.435 |
| 6.000 | 44.47 | 0.0 | 233.4 | -494.4 | 67.5 | 0 | -494.4 | 303.8 | 3.599 |
| 6.500 | 59.01 | 0.0 | 330.2 | -625.2 | 95.4 | 0 | -625.2 | 475.6 | 4.617 |
| 7.000 | 75.90 | 0.0 | 437.3 | -742.7 | 123.6 | 0 | -742.7 | 561.0 | 5.530 |
| 7.500 | 91.90 | 0.0 | 554.2 | -841.7 | 149.1 | 0 | -841.7 | 702.3 | 6.394 |
| 8.000 | 108.06 | 0.0 | 679.6 | -919.5 | 170.2 | 0 | -919.5 | 849.2 | 7.214 |
| 8.500 | 124.10 | 0.0 | 811.8 | -977.3 | 186.8 | 0 | -977.3 | 991.6 | 7.997 |
| 9.000 | 140.20 | 0.0 | 952.7 | -1016.0 | 198.8 | 0 | -1016.1 | 1151.5 | 8.746 |
| 9.500 | 156.33 | 0.0 | 1101.6 | -1036.4 | 206.1 | 0 | -1036.4 | 1307.6 | 9.465 |
| 10.000 | 172.40 | 0.0 | 1258.6 | -1039.2 | 208.4 | 0 | -1039.2 | 1466.9 | 10.160 |
| 11.000 | 204.60 | 0.0 | 1598.7 | -996.0 | 198.8 | 0 | -996.0 | 1795.5 | 11.486 |
| 12.000 | 236.93 | 0.0 | 1967.6 | -907.3 | 178.4 | 0 | -907.3 | 2145.4 | 12.834 |
| 12.500 | 252.56 | 0.0 | 2286.4 | -793.2 | 151.3 | 0 | -793.2 | 2437.7 | 14.064 |
| 13.000 | 268.93 | 0.0 | 2368.6 | -758.5 | 143.1 | 0 | -758.5 | 2511.6 | 14.308 |
| 14.000 | 290.71 | 0.0 | 2770.3 | -564.2 | 99.4 | 0 | -564.2 | 2869.7 | 15.669 |
| 15.000 | 325.03 | 0.0 | 3151.6 | -346.9 | 55.7 | 0 | -346.9 | 3207.3 | 17.555 |
| 16.000 | 347.80 | 0.0 | 3505.7 | -114.2 | 15.5 | 0 | -114.2 | 3521.1 | 19.506 |
| 16.495 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 1 | 0.0 | 3665.5 | 23.502 |
| 17.000 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 0 | 0.0 | 3665.5 | 23.502 |
| 17.659 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 1 | 0.0 | 3665.5 | 23.502 |
| 17.945 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 1 | 0.0 | 3665.5 | 23.502 |
| 18.000 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 0 | 0.0 | 3665.5 | 23.502 |
| 18.745 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 0 | 0.0 | 3665.5 | 23.502 |
| 18.332 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 1 | 0.0 | 3665.5 | 23.502 |
| 19.000 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 0 | 0.0 | 3665.5 | 23.502 |
| 20.000 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 0 | 0.0 | 3665.5 | 23.502 |
| 20.145 | 357.73 | 0.0 | 3665.5 | 0.0 | 0.0 | 1 | 0.0 | 3665.5 | 23.502 |

PARTLY DATA

1 SEC.

AREA AND HT. OF VOID AT FULLY

| VOID DEPTH (M) | VOID AREA (SQ.M) | CL MT (SQ.M*M) EVEN W.L. | BL MT (SQ.M*M) | VOID AREA (SQ.M) | CL MT (SQ.M*M) HEEL W.L. | BL MT (SQ.M*M) | ALLOW. VOID AREA (SQ.M) | EXCESS VOID AREA (SQ.M) | OVER VOID AREA (SQ.M) |
|---|---|---|---|---|---|---|---|---|---|
| 0.728 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

CMK. TOTAL TRANS.SEC. 0.0 VERT.SEC. 0.0
HT. CL HT. HEEL HT.
SEC.TOTAL TRANS.SEC. 0.0 VERT.SEC. 0.0
HEEL HT. HEEL HT.

FILLED DATA

SECTION AT FR.148.000 DIFFERENCE 0.440 M

| EVEN W.L. ABOVE BL (M) | SEC.AREA (SQ.M) | CL MT (SQ.M *M) EVEN W.L. | KG MT (SQ.M *M) EVEN W.L. | HEEL.HT OF SEC.AREA, KP (SQ.M *M) HEEL.ANGLE 25.0 DEG. (TRAN.) | (VERT.) | | CL MT (SQ.M *M) HEEL W.L. | KG MT (SQ.M *M) HEEL W.L. | HEEL W.L. ABOVE BL AT CL (M) |
|---|---|---|---|---|---|---|---|---|---|
| 1.995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | -3.601 |
| 2.500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |
| 3.000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | -3.601 |

GRAIN HEELING MT.

SUMMARY TABLE OF VOID DATA IN FILLED COMPARTMENT (WEDGE ANGLE 15.0 DEG.)

23 NO.3 CARGO HOLD (FR.148.000 - FR.175.000)
DIFF. 0.000 DIFF. 0.000
(UNDER UPPER DECK)

| COMPARTMENT | POSITION AFT FR. | AFT DIFF. | FORE FR. | FORE DIFF. | NO. | VOID DEPTH (M) | VOID VOLUME (CUB.M) | T.VOID VOLUME (CUB.M) | VOL.HEEL.MT. TRANS. (M**4) | VERT. (M**4) |
|---|---|---|---|---|---|---|---|---|---|---|
| AFT PART OF HATCH | 148.000 | 0.0 | 154.000 | 0.0 | 1 | 0.728 | 27.81 | | | |
| | | | | | | | SUB. TOTAL | 27.8 | 152.0 | -17.5 |
| HATCH PART | 154.000 | 0.0 | 169.000 | 0.0 | 1 | 0.150 | 147.57 | | | |
| | | | | | | | SUB. TOTAL | 147.6 | 546.5 | -74.9 |
| FORE PART OF HATCH | 169.000 | 0.0 | 175.000 | 0.0 | 1 | 0.728 | 50.30 | | | |
| | | | | | | | SUB. TOTAL | 50.3 | 274.9 | -31.7 |
| | | | | | | | DECK TOTAL | 225.7 | 973.4 | -124.2 |
| | | | | | | | GRAND TOTAL | 225.7 | 973.4 | -124.2 |

DETAIL OF VOLUMETRIC HEELING MOMENT AT FILLED COMPARTMENT (HEELING ANGLE 15.0 DEG.)

| NO. | COMPARTMENT NAME | POSITION AFT | FORE | VOLUME (CUB.M) | LCG (M) | KG (M) | TCG (M) | TRAN.VOL. HEEL.MT. (M**4) | VERT.VOL. HEEL.MT. (M**4) |
|---|---|---|---|---|---|---|---|---|---|
| 23 | NO.3 CARGO HOLD | (FR.148.000 - DIFF. 0.000 | FR.175.000) DIFF. 0.000 | 9861.69 | -33.273 | 10.124 | 0.0 | 973.4 | 124.2 |
| | AFT PART OF HATCH | (FR.148.000 - DIFF. 0.0 | FR.154.000) DIFF. 0.0 | | | | | 152.0 | 17.5 |
| | HATCH PART | (FR.154.000 - DIFF. 0.0 | FR.169.000) DIFF. 0.0 | | | | | 546.5 | 74.9 |
| | FORE PART OF HATCH | (FR.169.000 - DIFF. 0.0 | FR.175.000) DIFF. 0.0 | | | | | 274.9 | 31.7 |

23 NO.3 CARGO HOLD (FR.140.000 - FR.175.000) TANK BOTTOM = 1.995 M TANK TOP = 20.145 M
DIFF. 0.000 DIFF. 0.001

| W.L. ABOVE BL (M) | DEPTH ABOVE HD. BOTT. (M) | NET V. (CUB.M) | KG (M) | LCG (M) | TCG (M) | TRAN.VOL. HEEL.MT. (25.0 DEG) (M **4) | VERT.VOL. HEEL.MT. (25.0 DEG) (M **4) | KP |
|---|---|---|---|---|---|---|---|---|
| 1.995 | 0.0 | 0.0 | 1.995 | 0.0 | 0.0 | 0.0 | 0.0 | 1 |
| 2.500 | 0.505 | 235.43 | 2.516 | -33.841 | 0.0 | 2610.9 | 274.2 | 0 |
| 3.000 | 1.005 | 472.39 | 2.659 | -33.841 | 0.0 | 5099.9 | 703.7 | 0 |
| 3.240 | 1.245 | 587.40 | 2.726 | -33.841 | 0.0 | 6229.2 | 920.6 | 1 |
| 3.500 | 1.505 | 723.86 | 2.811 | -33.795 | 0.0 | 7536.7 | 1160.6 | 0 |
| 4.000 | 2.005 | 994.46 | 3.051 | -33.741 | 0.0 | 9903.9 | 1661.7 | 0 |
| 4.485 | 2.490 | 1266.41 | 3.311 | -33.712 | 0.0 | 12017.8 | 2137.4 | 1 |
| 5.000 | 3.005 | 1573.23 | 3.589 | -33.601 | 0.0 | 14369.4 | 2650.5 | 0 |
| 5.500 | 3.505 | 1880.71 | 3.851 | -33.531 | 0.0 | 16319.8 | 3134.3 | 0 |
| 6.000 | 4.005 | 2202.33 | 4.119 | -33.476 | 0.0 | 18124.9 | 3590.9 | 0 |
| 6.500 | 4.505 | 2533.00 | 4.379 | -33.432 | 0.0 | 19705.0 | 4001.1 | 0 |
| 7.000 | 5.005 | 2872.48 | 4.684 | -33.398 | 0.0 | 20981.0 | 4327.7 | 0 |
| 7.500 | 5.505 | 3216.38 | 4.958 | -33.370 | 0.0 | 21911.8 | 4549.6 | 0 |
| 8.000 | 6.005 | 3569.28 | 5.228 | -33.348 | 0.0 | 22409.4 | 4661.3 | 0 |
| 8.500 | 6.505 | 3904.18 | 5.494 | -33.330 | 0.0 | 22807.9 | 4700.8 | 0 |
| 9.000 | 7.005 | 4248.06 | 5.758 | -33.315 | 0.0 | 22928.9 | 4696.7 | 0 |
| 9.500 | 7.505 | 4591.96 | 6.019 | -33.302 | 0.0 | 22854.4 | 4650.1 | 0 |
| 10.000 | 8.005 | 4935.86 | 6.279 | -33.291 | 0.0 | 22592.2 | 4565.8 | 0 |
| 11.000 | 9.005 | 5623.64 | 6.795 | -33.273 | 0.0 | 21513.9 | 4294.4 | 0 |
| 12.000 | 10.005 | 6311.43 | 7.308 | -33.258 | 0.0 | 19710.9 | 3904.9 | 0 |
| 12.500 | 10.505 | 6661.66 | 7.716 | -33.249 | 0.0 | 17726.9 | 3512.5 | 0 |
| 13.000 | 11.005 | 6992.19 | 7.770 | -33.247 | 0.0 | 17157.8 | 3403.8 | 0 |
| 14.000 | 12.005 | 7622.52 | 8.207 | -33.238 | 0.0 | 14230.2 | 2897.6 | 0 |
| 15.000 | 13.005 | 8194.50 | 8.719 | -33.232 | 0.0 | 11414.1 | 2473.8 | 0 |
| 16.000 | 14.005 | 8680.78 | 9.095 | -33.228 | 0.0 | 8663.9 | 2043.6 | 0 |
| 16.495 | 14.490 | 8884.60 | 9.259 | -33.226 | 0.0 | 7351.6 | 1814.8 | 1 |
| 17.000 | 15.005 | 9072.54 | 9.416 | -33.235 | 0.0 | 6098.9 | 1560.7 | 0 |
| 17.659 | 15.664 | 9300.76 | 9.607 | -33.245 | 0.0 | 4541.2 | 1206.9 | 1 |
| 17.945 | 15.950 | 9390.25 | 9.683 | -33.254 | 0.0 | 3930.1 | 1055.5 | 1 |
| 18.000 | 16.005 | 9405.61 | 9.697 | -33.256 | 0.0 | 3823.5 | 1025.8 | 0 |
| 18.745 | 16.750 | 9613.79 | 9.885 | -33.275 | 0.0 | 2271.8 | 614.9 | 0 |
| 18.833 | 16.838 | 9635.66 | 9.905 | -33.277 | 0.0 | 2122.3 | 580.1 | 1 |
| 19.000 | 17.005 | 9664.43 | 9.932 | -33.276 | 0.0 | 1919.2 | 517.0 | 0 |
| 20.000 | 18.005 | 9836.71 | 10.099 | -33.273 | 0.0 | 738.3 | 118.1 | 0 |
| 20.145 | 18.150 | 9861.69 | 10.124 | -33.273 | 0.0 | 614.7 | 84.4 | 1 |

EVGN AT & DATA

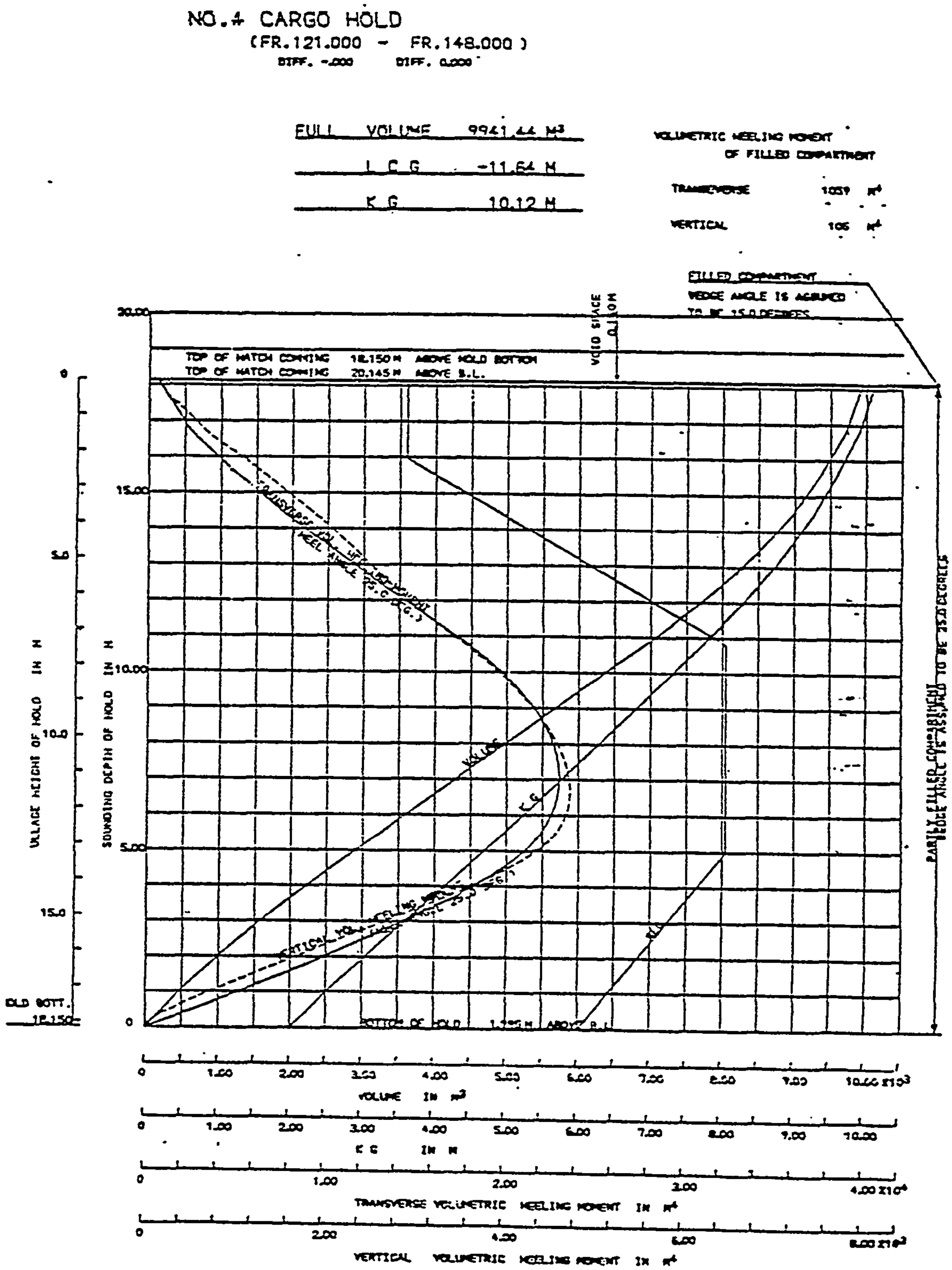
HOLD 7"-9

GRAIN HEELING MT.

SUMMARY TABLE OF VOLUMETRIC HEELING MOMENT AT FILLED COMPARTMENT (HEELING ANGLE 15.0 DEG.)

| NO. | COMPARTMENT | VOLUME (CUB.M ) | LCG (M ) | KG (M ) | TRAN.VOL. HEEL.MT. (M **4) | VERT.VOL. HEEL.MT. (M **4) |
|---|---|---|---|---|---|---|
| 21 | NO.1 CARGO HOLD | 7067.02 | -74.991 | 10.613 | 1021.8 | 100.4 |
| 22 | NO.2 CARGO HOLD | 9923.09 | -54.775 | 10.157 | 1131.2 | 112.4 |
| 23 | NO.3 CARGO HOLD | 9861.69 | -33.273 | 10.124 | 973.4 | 124.2 |
| 24 | NO.4 CARGO HOLD | 9941.45 | -11.637 | 10.121 | 1059.4 | 104.6 |
| 25 | NO.5 CARGO HOLD | 9967.70 | 9.908 | 10.141 | 1132.2 | 112.6 |
| 26 | NO.6 CARGO HOLD | 9041.70 | 31.770 | 10.172 | 1132.2 | 112.5 |
| 27 | NO.7 CARGO HOLD | 9106.09 | 52.760 | 10.569 | 1178.4 | 118.1 |
| 11 | NO.3 T.S.T. (P/S) | 1191.93 | -22.300 | 16.595 | 4266.6 | 1793.2 |
| | (S.SIDE) | | | | 4143.3 | 1792.9 |
| | (P.SIDE) | | | | 123.3 | 0.3 |
| 12 | NO.4 T.S.T. (P/S) | 1191.88 | 20.899 | 16.595 | 378.3 | 46.4 |
| | (S.SIDE) | | | | 252.1 | 33.6 |
| | (P.SIDE) | | | | 126.1 | 12.8 |
| 40 | NO.3 C.H.(IN DECK) | 11331.96 | -33.100 | 10.765 | 0.0 | 0.0 |
| 41 | NO.3 C.H. (CHECK) | 8354.00 | -33.100 | 9.680 | 0.0 | 0.0 |

# GRAIN HEELING MT.



タンクGG0

** GGO TABLE FOR OPERATINAL INFORMATION **

* OUTPUT UNIT SIGN= 0 * MINIMUM DISPT= 20000. * MAXIMUM DISPT= 50000. * INTERVAL DISPT= 500.

| TANK NO. | SG | WL(1) | INERTIA(1) | WL(2) | INERTIA(2) | WL(3) | INERTIA(3) | WL(4) | INERTIA(4) |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 7 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 8 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 9 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 10 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 11 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 13 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 14 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 15 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 16 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 17 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 18 | 1.025 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 19 | 0.950 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 20 | 0.950 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 21 | 0.950 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 22 | 0.900 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| 23 | 1.000 | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |

** CALCULATION TANK NO. ** * TITLE *

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 0 | 0 | 0 | 0 | BALLAST WATER |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FRESH WATER |
| 19 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FUEL OIL(C-OIL) |
| 21 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FUEL OIL(A-OIL) |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

*** GGO TABLE DISPLACEMENT DATA ***

* DISPT NO.= 61 * MINIMUM DISPT= 20000. * MAXIMUM DISPT= 50000. * INTERVAL DISPT= 500.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 20000. | 20500. | 21000. | 21500. | 22000. | 22500. | 23000. | 23500. | 24000. | 24500. |
| 25000. | 25500. | 26000. | 26500. | 27000. | 27500. | 28000. | 28500. | 29000. | 29500. |
| 30000. | 30500. | 31000. | 31500. | 32000. | 32500. | 33000. | 33500. | 34000. | 34500. |
| 35000. | 35500. | 36000. | 36500. | 37000. | 37500. | 38000. | 38500. | 39000. | 39500. |
| 40000. | 40500. | 41000. | 41500. | 42000. | 42500. | 43000. | 43500. | 44000. | 44500. |
| 45000. | 45500. | 46000. | 46500. | 47000. | 47500. | 48000. | 48500. | 49000. | 49500. |
| 50000. | | | | | | | | | |

DECREASE OF GM BY FREE SURFACE EFFECT
( UNIT : M )

| TANKS / DISPT. (MT) | BALLAST WATER NO.1 T. S. T. (P/S) S.G.=1.025 | NO.2 T. S. T. (P/S) S.G.=1.025 | NO.3 T. S. T. (P/S) S.G.=1.025 | NO.4 T. S. T. (P/S) S.G.=1.025 | NO.5 T. S. T. (P/S) S.G.=1.025 |
|---|---|---|---|---|---|
| 20000. | 0.032 | 0.040 | 0.040 | 0.040 | 0.042 |
| 20500. | 0.031 | 0.039 | 0.039 | 0.039 | 0.041 |
| 21000. | 0.033 | 0.038 | 0.038 | 0.038 | 0.040 |
| 21500. | 0.029 | 0.037 | 0.037 | 0.037 | 0.039 |
| 22000. | 0.029 | 0.036 | 0.036 | 0.036 | 0.038 |
| 22500. | 0.028 | 0.035 | 0.035 | 0.035 | 0.037 |
| 23000. | 0.027 | 0.034 | 0.035 | 0.035 | 0.037 |
| 23500. | 0.027 | 0.034 | 0.034 | 0.034 | 0.036 |
| 24000. | 0.026 | 0.033 | 0.033 | 0.033 | 0.035 |
| 24500. | 0.026 | 0.032 | 0.033 | 0.033 | 0.034 |
| 25000. | 0.025 | 0.032 | 0.032 | 0.032 | 0.034 |
| 25500. | 0.025 | 0.031 | 0.031 | 0.031 | 0.033 |
| 26000. | 0.024 | 0.031 | 0.031 | 0.031 | 0.032 |
| 26500. | 0.024 | 0.030 | 0.030 | 0.030 | 0.032 |
| 27000. | 0.023 | 0.029 | 0.030 | 0.030 | 0.031 |
| 27500. | 0.023 | 0.029 | 0.029 | 0.029 | 0.031 |
| 28000. | 0.023 | 0.028 | 0.028 | 0.028 | 0.030 |
| 28500. | 0.022 | 0.028 | 0.028 | 0.028 | 0.030 |
| 29000. | 0.022 | 0.027 | 0.027 | 0.027 | 0.029 |
| 29500. | 0.021 | 0.027 | 0.027 | 0.027 | 0.029 |
| 30000. | 0.021 | 0.026 | 0.027 | 0.027 | 0.028 |
| 30500. | 0.021 | 0.026 | 0.026 | 0.026 | 0.028 |
| 31000. | 0.020 | 0.026 | 0.026 | 0.026 | 0.027 |
| 31500. | 0.020 | 0.025 | 0.025 | 0.025 | 0.027 |
| 32000. | 0.020 | 0.025 | 0.025 | 0.025 | 0.026 |
| 32500. | 0.019 | 0.024 | 0.025 | 0.025 | 0.026 |
| 33000. | 0.019 | 0.024 | 0.024 | 0.024 | 0.026 |
| 33500. | 0.019 | 0.024 | 0.024 | 0.024 | 0.025 |
| 34000. | 0.019 | 0.023 | 0.023 | 0.023 | 0.025 |
| 34500. | 0.018 | 0.023 | 0.023 | 0.023 | 0.024 |
| 35000. | 0.018 | 0.023 | 0.023 | 0.023 | 0.024 |
| 35500. | 0.018 | 0.022 | 0.022 | 0.022 | 0.024 |
| 36000. | 0.018 | 0.022 | 0.022 | 0.022 | 0.023 |
| 36500. | 0.017 | 0.022 | 0.022 | 0.022 | 0.023 |
| 37000. | 0.017 | 0.021 | 0.022 | 0.022 | 0.023 |
| 37500. | 0.017 | 0.021 | 0.021 | 0.021 | 0.022 |
| 38000. | 0.017 | 0.021 | 0.021 | 0.021 | 0.022 |
| 38500. | 0.016 | 0.021 | 0.021 | 0.021 | 0.022 |
| 39000. | 0.016 | 0.020 | 0.020 | 0.020 | 0.022 |
| 39500. | 0.016 | 0.020 | 0.020 | 0.020 | 0.021 |

REMARK : THESE VALUES ARE SHOWN IN THE CASE OF THE MAXIMUM FREE SURFACE EFFECTS.

タンクGG0

トリムテーブル

```
*** CARD INPUT DATA ***

TITLE          TRIM TABLE - DRAFT CORRECTION TABLE BY LOADING UNIT WEIGHT

WEIGHT          100.00     (MT)

MIN. DRAFT        2.000    (M)

MAX. DRAFT       12.000    (M)

INTERVALS         0.500    (M)

UNIT              0

TANK NO.        6  7  8  9 10 11 13 14 15 16 17 18  0  0  0
               19 20 21 22 23  0  0  0  0  0  0  0  0  0  0
               31 32 33 34 35  0  0  0  0  0  0  0  0  0  0
                0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
                0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

ADDED DATA     TANK NO      TANK NAME          M.G(M)
                  0                             0.0
                  0                             0.0
                  0                             0.0
                  0                             0.0
                  0                             0.0
```

1行が1ページにOUTPUTされる.

TRIM TABLE

DRAFT (M)

| TANK NAME | | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
|---|---|---|---|---|---|---|---|
| NO.1 T. S. T. (P/S) | FWD | 9.1 | 8.9 | 8.7 | 8.6 | 8.5 | 8.5 |
| | AFT | -5.0 | -4.8 | -4.7 | -4.6 | -4.5 | -4.4 |
| NO.2 T. S. T. (P/S) | FWD | 6.2 | 6.1 | 6.0 | 5.9 | 5.9 | 5.9 |
| | AFT | -1.8 | -1.7 | -1.6 | -1.6 | -1.5 | -1.5 |
| NO.3 T. S. T. (P/S) | FWD | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 3.0 |
| | AFT | 1.9 | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 |
| NO.4 T. S. T. (P/S) | FWD | -0.2 | -0.1 | -0.1 | -0.0 | -0.0 | 0.0 |
| | AFT | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 5.0 |
| NO.5 T. S. T. (P/S) | FWD | -3.5 | -3.3 | -3.2 | -3.1 | -3.0 | -3.0 |
| | AFT | 9.2 | 9.0 | 8.8 | 8.6 | 8.4 | 8.3 |
| NO.1 W. B. T. (P/S) | FWD | 9.2 | 9.0 | 8.8 | 8.7 | 8.6 | 8.6 |
| | AFT | -5.1 | -4.9 | -4.8 | -4.7 | -4.6 | -4.5 |
| NO.3 W. B. T. (P/S) | FWD | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 |
| | AFT | 1.9 | 1.9 | 1.9 | 1.9 | 1.8 | 1.8 |
| NO.5 W. B. T. (P) | FWD | -3.4 | -3.2 | -3.1 | -3.0 | -2.9 | -2.9 |
| | AFT | 9.1 | 8.9 | 8.7 | 8.5 | 8.3 | 8.2 |
| NO.5 W. B. T. (S) | FWD | -3.2 | -3.0 | -2.9 | -2.8 | -2.7 | -2.7 |
| | AFT | 8.9 | 8.6 | 8.4 | 8.3 | 8.1 | 8.0 |
| FORE PEAK TANK | FWD | 11.6 | 11.3 | 11.1 | 11.0 | 10.8 | 10.8 |
| | AFT | -7.9 | -7.6 | -7.4 | -7.2 | -7.1 | -7.0 |
| AFT PEAK TANK | FWD | -8.3 | -8.0 | -7.8 | -7.6 | -7.5 | -7.4 |
| | AFT | 14.7 | 14.3 | 14.0 | 13.7 | 13.4 | 13.2 |
| NO.3 CARGO HOLD (WB) | FWD | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | AFT | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 | 1.7 |

REMARK : TABLE OF CHANGE IN DRAFT IN CENTIMETERS
FOR EACH 100. TONS ADDED.

トリムテーブル

TANK/HOLD CAPACITY SUMMARY TABLE **SN02581 ** DATE 77.11.16.

* CALCULATION UNIT SIGN = 0 0 0 0 0 0 0 0 0 0

*------* TANK/HOLD APPLICATION DATA **------**

KIND OF CARGO 1 TYPE OF TABLE 0 CARGO TITLE FRESH WATER TANK

TANK/HOLD NO. SUM1 23 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

CAPCITY(1) CUB.M CAPACITY(2) CUB.FT WEIGHT NAME OF CARGO WEIGHT %=100

CONVET (1) 1.00000 2 CONVET (2) 35.31467 1 CARGO SPECIFIC GRAVITY 1.00000 0 WEIGHT UNIT MT

*** FRESH WATER TANK *** S.G. = 1.000

| TANK NAME | FR.NO. | CAPACITY CUB.M | CAPACITY CUB.FT | WEIGHT 100 % FULL (MT) | CENTER OF GRAVITY LCG | CENTER OF GRAVITY K G |
|---|---|---|---|---|---|---|
| FRESH W. T. (P/S) | 9 - 17 | 385.39 | 13609.8 | 385. | 78.35 | 12.99 |

**------** TANK/HOLD APPLICATION DATA **------**

KIND OF CARGO 2 TYPE OF TABLE 0 CARGO TITLE FUEL OIL TANK

TANK/HOLD NO. SUM1 19 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

CAPCITY(1) CUB.M CAPACITY(2) BARREL WEIGHT NAME OF CARGO WEIGHT %= 96

CONVET (1) 1.00000 2 CONVET (2) 6.20981 1 CARGO SPECIFIC GRAVITY 0.95000 0 WEIGHT UNIT MT

# タンク等サマリーテーブル
# 〔標準 FORM〕

| FRESH WATER TANK S.G. = 1.000 | | | | | | |
|---|---|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | | WEIGHT | CENTER OF GRAVITY | |
| | | CUB.M | CUB.FT | 100 % FULL (MT) | LCG (M) | KG (M) |
| FRESH W. T. (P/S) | 9- 17 | 385.39 | 13609.8 | 385 | 78.35 | 12.99 |

| FUEL OIL TANK S.G. = 0.950 | | | | | | |
|---|---|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | | WEIGHT | CENTER OF GRAVITY | |
| | | CUB.M | BARREL | 96 % FULL (MT) | LCG (M) | KG (M) |
| NO.2 F. O. T. (P/S) | 139- 173 | 1526.55 | 9601.7 | 1392 | -36.65 | 1.45 |
| NO.4 F. O. T. (P/S) | 71- 105 | 1547.53 | 9733.7 | 1411 | 17.58 | 1.44 |
| TOTAL | | 3074.08 | 19335.4 | 2803 | ——— | ——— |

| DIESEL OIL TANK S.G. 0.900 | | | | | | |
|---|---|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | | WEIGHT | CENTER OF GRAVITY | |
| | | CUB.M | BARREL | 96 % FULL (MT) | LCG (M) | KG (M) |
| F. O. T.(A-OIL) (P) | 15- 39 | 97.43 | 612.8 | 84 | 65.03 | 0.97 |
| F. O. T.(A-OIL) (S) | 17- 39 | 96.44 | 606.6 | 83 | 64.72 | 0.99 |
| TOTAL | | 193.87 | 1219.4 | 167 | ——— | ——— |

| WATER BALLAST TANK S.G. = 1.025 | | | | | | |
|---|---|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | | WEIGHT | CENTER OF GRAVITY | |
| | | CUB.M | CUB.FT | 100 % FULL (MT) | LCG (M) | KG (M) |
| NO.1 T. S. T. (P/S) | 174- 209 | 733.28 | 25895.6 | 752 | -61.55 | 14.10 |
| NO.2 T. S. T. (P/S) | 140- 174 | 993.68 | 35091.4 | 1019 | -37.33 | 13.59 |
| NO.3 T. S. T. (P/S) | 106- 140 | 999.54 | 35298.4 | 1025 | -10.19 | 13.59 |
| FORE PEAK TANK | 207- 215 | 1596.00 | 56362.2 | 1636 | -82.83 | 8.26 |
| AFT PEAK TANK | -6- 8 | 283.46 | 10010.2 | 291 | 85.96 | 10.86 |
| SUB TOTAL | | 10531.22 | 371907.0 | 10797 | ——— | ——— |
| NO.3 CARGO HOLD (WB) | 106- 140 | 9447.63 | 333640.0 | 9684 | -10.42 | 8.71 |
| SUB TOTAL | | 9447.63 | 333640.0 | 9684 | ——— | ——— |
| GRAND TOTAL | | 19978.85 | 705547.0 | 20481 | ——— | ——— |

## タンク等サマリーテーブル

## 〔変則 FORM〕

| FUEL OIL TANK | | | | | |
|---|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | | CENTER OF GRAVITY | |
| | | CUB.M | BARREL | LCG (M) | K G (M) |
| NO.2 F. O. T. (P/S) | 139- 173 | 1526.55 | 9601.7 | -36.65 | 1.45 |
| NO.4 F. O. T. (P/S) | 71- 105 | 1547.53 | 9733.7 | 17.58 | 1.44 |
| TOTAL | | 3074.08 | 19335.4 | ——— | ——— |

| WATER BALLAST TANK | | | | |
|---|---|---|---|---|
| TANK NAME | FR.NO. | CAPACITY | CENTER OF GRAVITY | |
| | | CUB.M | LCG (M) | K G (M) |
| NO.1 T. S. T. (P/S) | 174- 209 | 733 | -61.55 | 14.10 |
| NO.2 T. S. T. (P/S) | 140- 174 | 994 | -37.33 | 13.89 |
| NO.3 T. S. T. (P/S) | 106- 140 | 1000 | -10.19 | 13.89 |
| NO.4 T. S. T. (P/S) | 72- 106 | 1000 | 17.01 | 13.89 |
| NO.5 T. S. T. (P/S) | 36- 72 | 1045 | 44.86 | 13.91 |
| NO.1 W. B. T. (P/S) | 173- 209 | 1081 | -62.48 | 1.31 |
| SUB TOTAL | | 5853 | ——— | ——— |
| NO.3 W. B. T. (P/S) | 105- 139 | 1551 | -9.50 | 1.44 |
| NO.5 W. B. T. (P) | 36- 71 | 667 | 43.97 | 2.12 |
| NO.5 W. B. T. (S) | 36- 71 | 581 | 42.24 | 1.82 |
| FORE PEAK TANK | 207- 215 | 1596 | -82.83 | 8.25 |
| AFT PEAK TANK | -6- 8 | 283 | 85.96 | 10.86 |
| SUB TOTAL | | 4678 | ——— | ——— |
| NO.3 CARGO HOLD (WB) | 106- 140 | 9448 | -10.42 | 8.71 |
| SUB TOTAL | | 9448 | ——— | ——— |
| GRAND TOTAL | | 19979 | ——— | ——— |

```
** CHECK PRINT OF CARD INPUT DATA **

B5JA10    TRIM CALCULATION

TRIMGO    0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

TRIM 1    0  0  0  0  0  0

TRIM 2    520296.00    9.770   6.200   6.958

TRIM 3    62679.000   6.660 417440.00  17.7201110670.00

TRIM 4    540.000 107.740  59050.00  16.440   9010.00

TRIK 1     1    1 0   1.0000 0.0
TRIK 2     2    1 0   1.0000 0.0
TRIK 3     3    1 0   1.0000 0.0
TRIK 4    20    1 0   1.0000 0.0
TRIK 5     4    2 0   0.9500 0.0
TRIK 6     5    2 0   0.9500 0.0
TRIK 7     6    2 0   0.9500 0.0
TRIK 8     7    3 0   0.9000 0.0
TRIK 9     8    4 0   1.0250 0.0
TRIK10     9    4 0   1.0250 0.0
TRIK11    10    4 0   1.0250 0.0
TRIK12    11    4 0   1.0250 0.0
TRIK13    12    4 0   1.0250 0.0
TRIK14    13    4 0   1.0250 0.0
TRIK15    14    5 4   0.0    0.0
TRIK16    15    5 4   0.0    0.0
TRIK17    16    5 4   0.0    0.0
TRIK18    17    5 4   0.0    0.0
TRIK19    18    5 4   0.0    0.0
TRIK20    19    5 4   0.0    0.0
TRIK21    21    5 4   0.0    0.0
TRIK22    22    5 4   0.0    0.0
TRIK23    23    5 4   0.0    0.0
TRIK24    24    5 4   0.0    0.0
TRIK25    25    5 4   0.0    0.0
TRIK26    26    5 4   0.0    0.0
TRIK27    27    5 4   0.0    0.0
TRIK28    28    5 4   0.0    0.0
TRIK29    29    5 4   0.0    0.0
TRIK30    30    5 4   0.0    0.0
TRIK31    31    5 4   0.0    0.0
TRIK32    32    5 4   0.0    0.0
TRIK33    33    5 4   0.0    0.0
TRIK34    34    5 4   0.0    0.0

TRGO 1     1  2  3  4  0  0  0  0
TRGO 2     5  6  7  8  9  0  0  0
TRGO 3    10 11 12 13 14 15 16 17
TRGO 4    18 19 20 21  0 22 23 24
```

トリム計算

```
CONDITION NO. = 4                                    *** CONDITION CALCULATION START ***

** CHECK WRITE OF CARD INPUT DATA **

TRCOND   4FULL LOAD   CONDITION   AT UKC ARR.              ONEWAY BUNK.

TRCDG1  H0M0    0    0

TRCDG2  513175.000  0.0    0.0    0.0    0.0    0.0   0.0

TRCDC1   0 0.0     0.0  14 15 16 17 18 19  0  0  0  0  0  0  0  0  0  0  0  0
TRCDC2   0 0.0     0.0  21 22 23 24 25 26 27 28 29 30 31 32 33 34  0  0  0  0

TRCDBE   1

TRCDB1   1  2  3 20  7  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
TRCDB2   8  9 10 11 12 13  0  0  0  0  0  0  0  0  0  0  0  0  0  0

TRIM 1   4     0.0     0.0      0.0     0.0      0.0
TRIM 2   5     0.0     0.0      0.0     0.0      0.0
TRIM 3   6     0.0   911.00     0.0     0.0      0.0
```

FULL LOAD CONDITION AT UKC ARR. ONEWAY BUNK. (1/2)

| | | | |
|---|---|---|---|
| FRESH WATER | = | 780 | MT |
| FUEL OIL | = | 911 | MT |
| DIESEL OIL | = | 150 | MT |
| WATER BALLAST | = | 0 | MT |
| CARGO OIL | = | 448107 | MT |
| CONSTANTS | = | 548 | MT |
| DEADWEIGHT | = | 450496 | MT |
| LIGHT WEIGHT | = | 62679 | MT |
| DISPLACEMENT | = | 513175 | MT |
| CORRESPONDING DRAFT | = | 24.72 | M |
| T P C | = | 225.23 | MT |
| L C G | = | -15.30 | M |
| L C B | = | -15.30 | M |
| M T C | = | 5734.5 | MT- M |
| TRIM | = | 0.0 | M |
| L C F | = | -4.17 | M |
| DRAFT AT F.P. | = | 24.72 | M |
| DRAFT AT A.P. | = | 24.72 | M |
| DRAFT (MEAN) | = | 24.72 | M |
| PROPELLER IMMERSION | = | 232 | % |
| T KM | = | 27.77 | M |
| K G | = | 16.34 | M |
| G GO | = | 1.11 | M |
| GO M | = | 10.32 | M |
| MOMENT TO HEEL 1 DEG. | = | 92448 | MT- M |

NOTE 1 - SIGN SHOWS FORWARD FROM MIDSHIP.

トリム計算

FULL LOAD CONDITION . AT UKC ARR. ONEWAY BUNK. (2/2)

| ITEMS | % | WEIGHT (MT) | L C G (M) | MOMENT (MT-M) | K G (M) | MOMENT (MT-M) | G GO (M) |
|---|---|---|---|---|---|---|---|
| LIGHT WEIGHT | | 62679 | 6.66 | 417440 | 17.72 | 1110670 | |
| CONSTANTS | | 549 | 107.74 | 59050 | 16.44 | 9010 | |
| FRESH WATER T. (P/S) | 59 | 250 | 170.22 | 42555 | 28.50 | 7125 | 0.0 |
| DRINK WATER T. (P) | 58 | 132 | 170.55 | 22155 | 28.20 | 3646 | 0.0 |
| DIST. WATER T. (P) | 53 | 210 | 164.34 | 34511 | 25.99 | 5458 | 0.0 |
| DIST. WATER T. (S) | 98 | 190 | 165.82 | 31506 | 28.26 | 5369 | 0.0 |
| (FRESH WATER TOTAL) | | ( 750) | | ( 130730) | | ( 21592) | ( 0.0 ) |
| FORE FUEL OIL TANK | 0 | 0 | -157.57 | 0 | 0.0 | 0 | 0.0 |
| AFT FUEL OIL T.(P/S) | 0 | 0 | 137.03 | 0 | 0.0 | 0 | 0.0 |
| FUEL O.SETT.T. (P/S) | 53 | 911 | 155.95 | 142070 | 25.35 | 23094 | 0.0 |
| (FUEL OIL TOTAL) | | ( 911) | | ( 142070) | | ( 23094) | ( 0.0 ) |
| DIESEL OIL TANK | 79 | 150 | 162.02 | 24303 | 27.07 | 4060 | 0.0 |
| (DIESEL OIL TOTAL) | | ( 150) | | ( 24303) | | ( 4060) | ( 0.0 ) |
| FORE PEAK TANK | 0 | 0 | -172.62 | 0 | 0.0 | 0 | 0.0 |
| NO.3 W. B. T. (C) | 0 | 0 | -89.50 | 0 | 0.0 | 0 | 0.0 |
| NO.6 W. B. T. (C) | 0 | 0 | 23.70 | 0 | 0.0 | 0 | 0.0 |
| RESERVE W.B.T. (C) | 0 | 0 | 125.75 | 0 | 0.0 | 0 | 0.0 |
| RESERVE W.B.T. (P/S) | 0 | 0 | 127.39 | 0 | 0.0 | 0 | 0.0 |
| AFT PEAK TANK | 0 | 0 | 175.05 | 0 | 0.0 | 0 | 0.0 |
| (W. BALLAST TOTAL) | | ( 0) | | ( 0) | | ( 0) | ( 0.0 ) |
| NO.1 C. O. T. (C) | 47 | 7194 | -151.45 | -1089531 | 8.10 | 58271 | 0.04 |
| NO.2 C. O. T. (C) | 99 | 24581 | -119.13 | -2928334 | 16.08 | 395262 | 0.06 |
| NO.4 C. O. T. (C) | 90 | 12271 | -68.10 | -835655 | 16.06 | 197072 | 0.03 |
| NO.5 C. O. T. (C) | 98 | 36813 | -27.30 | -1004994 | 16.06 | 591217 | 0.10 |
| NO.7 C. O. T. (C) | 98 | 24335 | 64.50 | 1582500 | 16.07 | 394277 | 0.06 |
| NO.9 C. O. T. (C) | 98 | 23615 | 104.64 | 2471388 | 16.57 | 391350 | 0.06 |
| NO.1 C. O. T. (P/S) | 98 | 21172 | -150.41 | -3184480 | 17.16 | 363311 | 0.02 |
| NO.2 C. O. T. (P/S) | 98 | 23001 | -129.13 | -2970119 | 16.05 | 369936 | 0.05 |
| NO.3 C. O. T. (P/S) | 98 | 24155 | -108.89 | -2630238 | 15.82 | 382132 | 0.06 |
| NO.4 C. O. T. (P/S) | 98 | 24274 | -88.39 | -2143024 | 15.78 | 382255 | 0.06 |
| NO.5 C. O. T. (P/S) | 98 | 24224 | -68.10 | -1649654 | 15.78 | 382255 | 0.06 |
| NO.6 C. O. T. (P/S) | 98 | 24224 | -47.79 | -1159495 | 15.78 | 382255 | 0.06 |
| NO.7 C. O. T. (P/S) | 98 | 24225 | -27.30 | -661342 | 15.78 | 382270 | 0.06 |
| NO.8 C. O. T. (P/S) | 99 | 24224 | -6.90 | -167146 | 15.78 | 382255 | 0.06 |
| NO.9 C. O. T. (P/S) | 99 | 24221 | 13.50 | 326994 | 15.70 | 382207 | 0.06 |
| NO.10 C. O. T. (P/S) | 93 | 24127 | 33.99 | 817665 | 15.85 | 382172 | 0.06 |
| NO.11 C. O. T. (P/S) | 98 | 23706 | 54.25 | 1286051 | 16.09 | 381429 | 0.06 |
| NO.12 C. O. T. (P/S) | 99 | 22491 | 74.56 | 1676929 | 16.67 | 374925 | 0.05 |
| NO.13 C. O. T. (P/S) | 90 | 19763 | 94.79 | 1873335 | 17.66 | 349014 | 0.06 |
| SLOP TANK (P/S) | 98 | 15330 | 116.93 | 1762796 | 19.27 | 295563 | 0.04 |
| (CARGO OIL TOTAL) | | ( 448107) | | ( -8625147) | | ( 7215428) | ( 1.11 ) |
| GRAND TOTAL | | 513175 | -15.30 | -7849554 | 16.34 | 8386854 | 1.11 |

NOTE : - SIGN SHOWS FORWARD FROM MIDSHIP.

SUMMARY TABLE OF STANDARD LOADING CONDITION ( / )

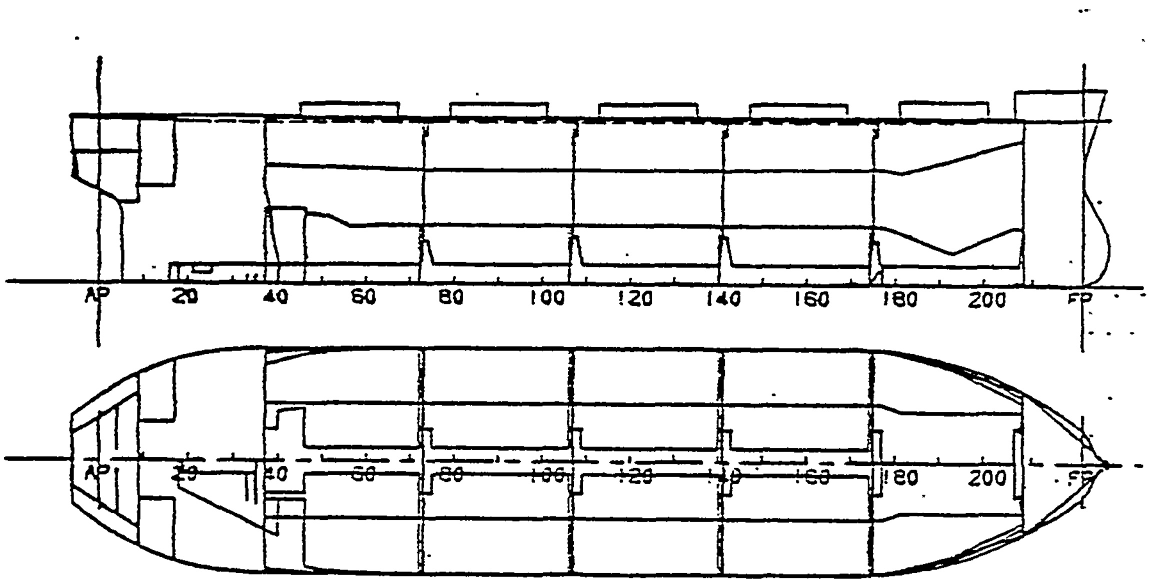
| ITEMS | CONDITIONS | 49% UNLOAD. CONDITION AT UKC ARR. ONEWAY BUNK. | 51% UNLOAD. CONDITION AT UKC ARR. ONEWAY BUNK. | 25% UNLOAD. CONDITION AT UKC ARR. ONEWAY BUNK. | 75% UNLOAD. CONDITION AT UKC ARR. ONEWAY BUNK. | | PORT CONDITION AT MINA AL AHMADI NEW FACILITY | TAIL SHAFT AFLOAT CONDITION | DOCKING CONDITION |
|---|---|---|---|---|---|---|---|---|---|
| FRESH WATER | MT | 780 | 780 | 780 | 780 | 0 | 780 | 0 | 780 |
| FUEL OIL | MT | 911 | 911 | 911 | 911 | 0 | 797 | 0 | 797 |
| DIESEL OIL | MT | 150 | 150 | 150 | 150 | 0 | 150 | 0 | 150 |
| WATER BALLAST | MT | 0 | 45918 | 30601 | 19000 | 0 | 149300 | 9861 | 40147 |
| CARGO OIL | MT | 225387 | 222720 | 343073 | 105034 | 0 | 0 | 0 | 0 |
| CONSTANTS | MT | 548 | 548 | 548 | 548 | 0 | 548 | 548 | 548 |
| DEADWEIGHT | MT | 227776 | 271077 | 376063 | 126423 | 0 | 151575 | 10409 | 42422 |
| LIGHT WEIGHT | MT | 62679 | 62679 | 62679 | 62679 | 0 | 62679 | 62679 | 62679 |
| DISPLACEMENT | MT | 290455 | 333706 | 438742 | 189102 | 0 | 214254 | 73088 | 105101 |
| CORRESPONDING DRAFT | M | 14.53 | 16.56 | 21.38 | 9.68 | 0.0 | 10.89 | 3.93 | 5.55 |
| T P C | MT | 211.58 | 214.30 | 229.74 | 205.93 | 0.0 | 207.43 | 195.54 | 199.53 |
| L C G | M | -9.36 | -14.95 | -13.91 | -4.86 | 0.0 | -10.75 | -13.91 | -23.14 |
| L C B | M | -20.05 | -19.22 | -16.96 | -21.75 | 0.0 | -21.34 | -23.73 | -23.14 |
| M T C | MT- M | 4795.5 | 4965.4 | 5411.2 | 4470.0 | 0.0 | 4566.3 | 3973.3 | 4153.7 |
| TRIM | M | 6.49 | 2.87 | 2.47 | 7.19 | 0.0 | 4.99 | 1.81 | 0.0 |
| L C F | M | -14.85 | -12.55 | -6.99 | -18.88 | 0.0 | -18.02 | -22.38 | -21.44 |
| DRAFT AT F.P. | M | 11.55 | 15.22 | 20.19 | 6.48 | 0.0 | 8.65 | 3.14 | 5.55 |
| DRAFT AT A.P. | M | 18.04 | 18.09 | 22.66 | 13.63 | 0.0 | 13.64 | 4.95 | 5.55 |
| DRAFT (MEAN) | M | 14.79 | 16.65 | 21.43 | 10.05 | 0.0 | 11.14 | 4.04 | 5.55 |
| PROPELLER IMMERSION | % | 162 | 165 | 210 | 117 | 0 | 118 | 29 | 36 |
| T KM | M | 30.70 | 30.36 | 28.19 | 41.54 | 0.0 | 38.21 | 89.18 | 65.43 |
| K G | M | 16.26 | 16.74 | 16.56 | 15.56 | 0.0 | 16.49 | 16.54 | 13.37 |
| G GO | M | 1.07 | 0.82 | 0.98 | 1.11 | 0.0 | 0.21 | 0.32 | 1.37 |
| GO M | M | 14.87 | 12.80 | 10.65 | 24.87 | 0.0 | 21.51 | 72.32 | 50.49 |
| MOMENT TO HEEL 1 DEG. | MT- M | 75411 | 74579 | 81584 | 87114 | 0 | 80465 | 92289 | 93019 |

NOTE ( - ) SIGN SHOWS FORWARD FROM MIDSHIP.

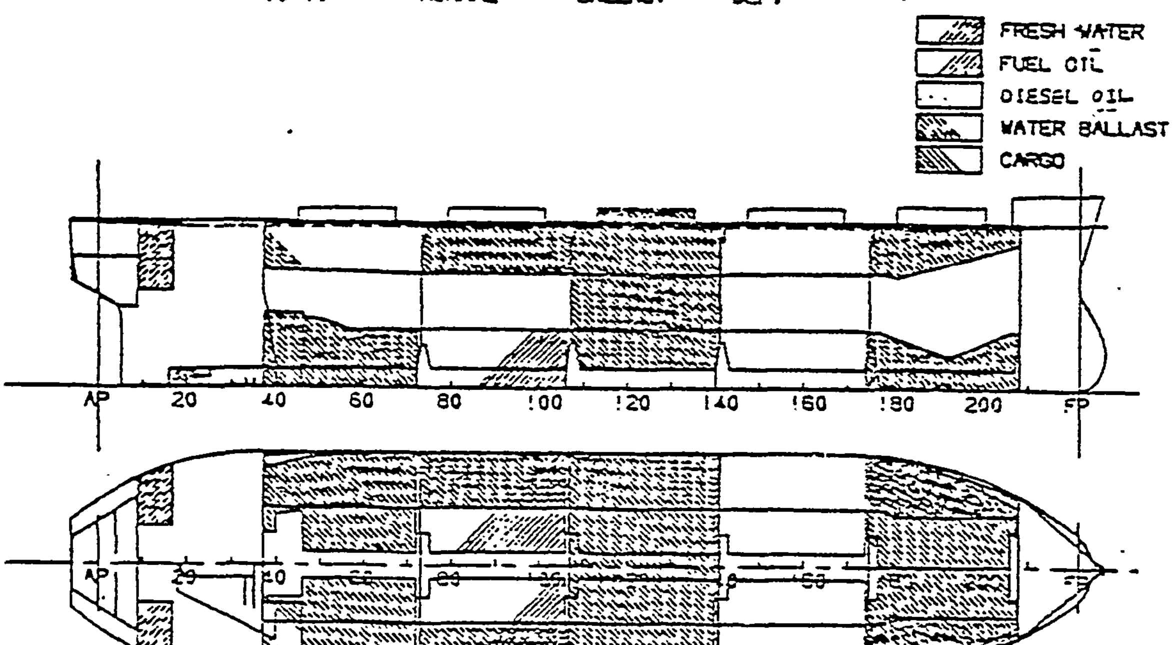
トリム計算

# トリム計算（積付状態作画）

GENERAL ARRANGEMENT　　SCALE : 1/1186




(C-1)　NORMAL　BALLAST　DEP.



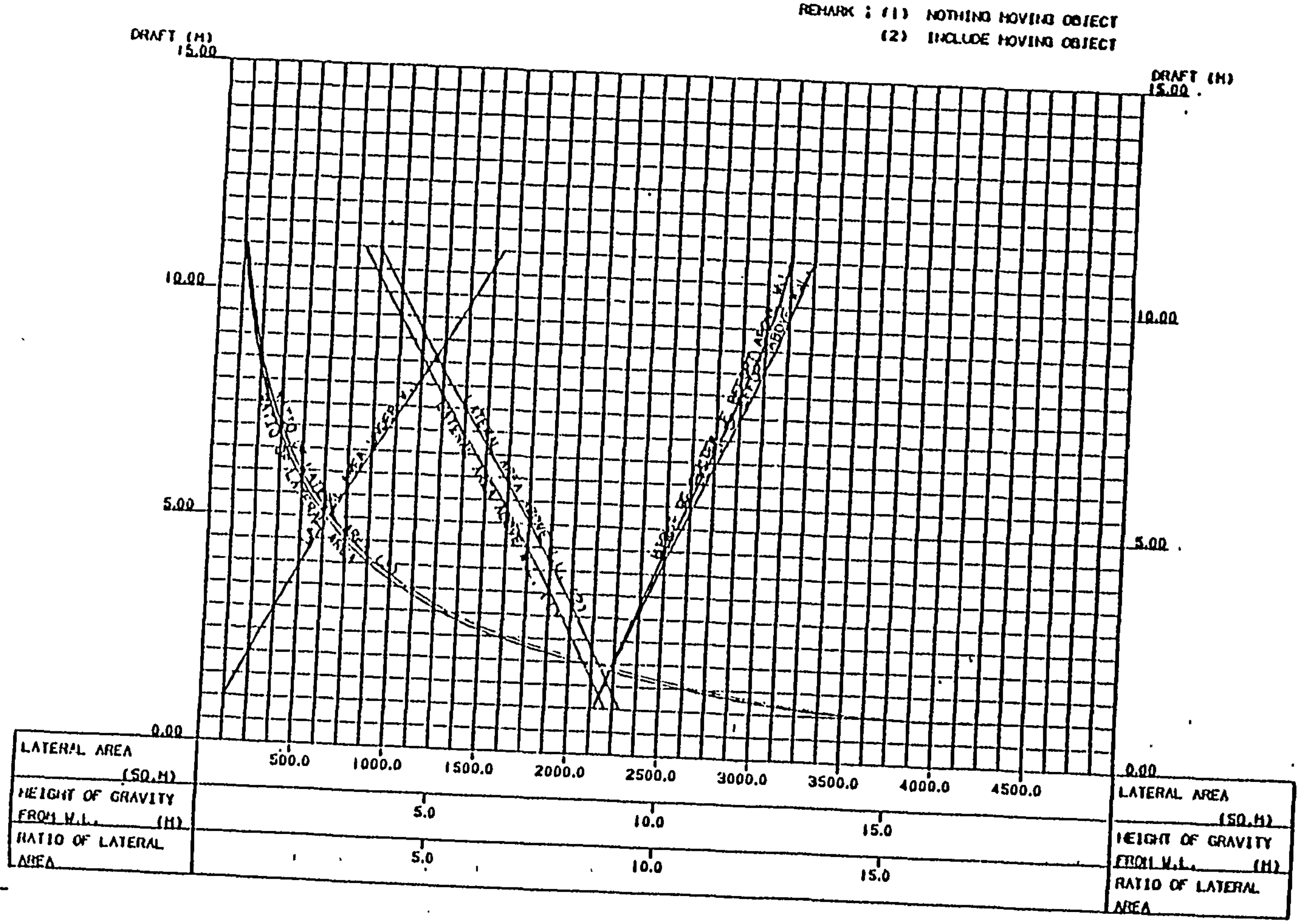
## *** LATERAL AREA CURVE ***

| DRAFT (M) | UNDER WATER LINE AREA (SQ.M) | UNDER WATER LINE K G (M) | ABOVE WATER LINE AREA (SQ.M) | ABOVE WATER LINE K G (M) | AREA RATIO | INCLUDE MOVING OBJECT: ABOVE WATER LINE AREA (SQ.M) | INCLUDE MOVING OBJECT: ABOVE WATER LINE K G (M) | INCLUDE MOVING OBJECT: AREA RATIO |
|---|---|---|---|---|---|---|---|---|
| 1.000 | 194.30 | 0.50 | 3612.14 | 10.17 | 18.590 | 3612.14 | 10.17 | 18.590 |
| 2.000 | 390.23 | 1.00 | 3416.21 | 10.66 | 8.754 | 3416.21 | 10.66 | 8.754 |
| 3.000 | 586.84 | 1.50 | 3219.60 | 11.16 | 5.486 | 3219.60 | 11.16 | 5.486 |
| 4.000 | 783.76 | 2.01 | 3022.68 | 11.66 | 3.857 | 3022.68 | 11.66 | 3.857 |
| 5.000 | 980.74 | 2.51 | 2825.71 | 12.16 | 2.881 | 2825.71 | 12.16 | 2.881 |
| 6.000 | 1177.51 | 3.01 | 2628.94 | 12.66 | 2.233 | 2628.94 | 12.66 | 2.233 |
| 7.000 | 1373.78 | 3.51 | 2432.67 | 13.15 | 1.771 | 2432.67 | 13.15 | 1.771 |
| 8.000 | 1569.50 | 4.00 | 2236.95 | 13.65 | 1.425 | 2236.95 | 13.65 | 1.425 |
| 9.000 | 1765.30 | 4.50 | 2041.14 | 14.14 | 1.156 | 2041.14 | 14.14 | 1.156 |
| 10.000 | 1962.19 | 5.00 | 1844.26 | 14.64 | 0.940 | 1844.26 | 14.64 | 0.940 |
| 11.000 | 2160.35 | 5.51 | 1646.10 | 15.14 | 0.762 | 1646.10 | 15.14 | 0.762 |
| 12.000 | 2359.73 | 6.01 | 1446.72 | 15.64 | 0.613 | 1446.72 | 15.64 | 0.613 |
| 13.000 | 2560.22 | 6.52 | 1246.23 | 16.14 | 0.487 | 1246.23 | 16.14 | 0.487 |
| 14.000 | 2761.47 | 7.03 | 1044.98 | 16.65 | 0.378 | 1044.98 | 16.65 | 0.378 |
| 15.000 | 2963.27 | 7.54 | 843.17 | 17.17 | 0.285 | 843.17 | 17.17 | 0.285 |
| 16.000 | 3165.77 | 8.05 | 640.68 | 17.69 | 0.202 | 640.68 | 17.69 | 0.202 |
| 17.000 | 3368.54 | 8.56 | 437.50 | 18.25 | 0.130 | 437.50 | 18.25 | 0.130 |
| 18.000 | 3572.79 | 9.07 | 233.65 | 18.90 | 0.065 | 233.65 | 18.90 | 0.065 |
| 18.300 | 3634.08 | 9.22 | 172.37 | 19.17 | 0.047 | 172.37 | 19.17 | 0.047 |

風圧側面積

風圧側面積

CURVE OF LATERAL AREA



## SUMMARY TABLE OF STABILITY CALCULATION

| COND. NO. | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|
| | HEAVY BALL. JAPAN DEP. | NORMAL BALL. JAPAN DEP. | ORE ALTERNATE HUASCO DEP. | HOMOGENEOUS NOFOLK DEP. | GRAIN LOAD. S.F.=40 VANCOUVER DEPARTURE | GRAIN LOAD. S.F.=55 VANCUUVER DEPARTURE |
| | (T.C.=1) | (T.C.=3) | (T.C.=9) | (T.C.=11) | (T.C.=21) | (T.C.=29) |
| DISPLACEMENT(MT) | 39630.0 | 32570.0 | 70965.0 | 70965.0 | 70917.0 | 56137.0 |
| DRAFT (CORR) (M) | 7.743 | 6.434 | 13.330 | 13.330 | 13.330 | 10.736 |
| DRAFT AT AP (M) | 8.480 | 8.480 | 13.340 | 13.330 | 13.330 | 10.730 |
| DRAFT AT FP (M) | 7.080 | 4.640 | 13.340 | 13.330 | 13.330 | 10.730 |
| DRAFT (MEAN) (M) | 7.740 | 6.560 | 13.340 | 13.330 | 13.330 | 10.730 |
| TRIM (M) | 1.400 | 3.840 | 0.0 | 0.0 | 0.0 | 0.0 |
| KG (M) | 9.670 | 10.760 | 10.200 | 10.190 | 10.240 | 10.420 |
| GM (M) | 4.740 | 5.540 | 2.970 | 2.900 | 2.930 | 2.760 |
| GGO (M) | 0.770 | 0.600 | 0.260 | 0.260 | 0.120 | 0.220 |
| GOM (M) | 3.970 | 4.940 | 2.710 | 2.720 | 2.810 | 2.540 |
| OG (M) | 1.927 | 3.026 | -3.130 | -3.140 | -3.090 | -0.316 |
| GZ MAX. (M) | 3.155 | 3.120 | 1.247 | 1.353 | 1.413 | 2.138 |
| THETA MAX. (DEG) | 42.265 | 42.034 | 38.013 | 38.821 | 40.000 | 40.757 |
| THETA RANGE (DEG) | 83.022 | 81.070 | 76.150 | 76.329 | 77.974 | 78.621 |
| D.S. (M-RAD) | 2.637 | 2.684 | 1.111 | 1.117 | 1.178 | 1.609 |
| D.S. (MT-M) | 104501.3 | 87444.1 | 78817.7 | 79283.9 | 83567.4 | 90313.6 |
| D.S./DISP (M) | 2.637 | 2.684 | 1.111 | 1.117 | 1.178 | 1.609 |
| FLOOD.ANGLE (DEG) | | | | | | |
| LAT.W.AREA (M2) | 2286.9 | 2543.5 | 1170.4 | 1170.4 | 1180.1 | 1699.3 |
| LAT.AREA RATIO | 1.428 | 1.951 | 0.444 | 0.444 | 0.445 | 0.781 |
| ROLL.PERIOD TS | 12.120 | 11.365 | 13.527 | 13.502 | 13.205 | 14.290 |
| RED. COEFF. N | 0.02364 | 0.02612 | 0.01985 | 0.01983 | 0.01991 | 0.02214 |
| ROLL.ANGLE (DEG) | 18.090 | 19.930 | 14.814 | 14.838 | 15.056 | 14.616 |
| RESULT C1 | 11.995 | 7.965 | 11.644 | 11.644 | 11.665 | 10.313 |
| GZ REQ. (M) | | | | | | |
| GZ MAX./GZ REQ | | | | | | |
| THETA MAX/30. | 1.409 | 1.428 | 1.294 | 1.294 | 1.333 | 1.359 |
| RESULT C2 | 0.033 | 0.046 | 0.023 | 0.022 | 0.022 | 0.026 |
| FREEBOARD AT FP | 11.709 | 14.149 | 5.449 | 5.459 | 5.459 | 8.059 |
| FREEBOARD AT MID | 10.520 | 11.740 | 4.960 | 4.970 | 4.970 | 7.570 |
| FREEBOARD AT AP | 10.177 | 10.177 | 5.317 | 5.327 | 5.327 | 7.927 |
| RES.DISP (MT) | 63090.1 | 70150.1 | 31771.1 | 31771.1 | 31819.1 | 46599.1 |
| RES.DISP/A.DISP | 1.592 | 2.154 | 0.448 | 0.448 | 0.449 | 0.830 |

COND 3 NORMAL BALL. JAPAN DEP.

** PARTICULARS FOR STABILITY

DISPLACEMENT 10662. MT DRAFT AT AP 4.380 M
DRAFT AT FP 0.470 M
CORRECTED KG (KGO) 11.220 M
CORRECTED GM (GOM) 24.120 M

** RIGHTING LEVER (GZ) CURVE INFORMATION

RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 76.60 DEG.
MAX.RIGHTING LEVER 5.026 M AT 20.63 DEG.
ANGLE OF FLOODING INTO MAIN HULL NOTHING

INTEGRATED AREA FOR DYNAMICAL STABILITY
AREA-1 2.052 M-RAD. FROM 0.0 DEG. TO 30.00 DEG.
AREA-2 2.795 M-RAD. FROM 0.0 DEG. TO 40.00 DEG.
AREA-3 0.743 M-RAD. FROM 30.00 DEG. TO 40.00 DEG.

HEELING ANGLE AT 42.42 DEG. (DECK SIDE LINE WILL BE IMMERSED)

** STABILITY STUDY WITH WIND AND ROLLING

RIGHTING LEVER AT STEADY WIND OW1 = 0.244 M (COEFF. K1 = 0.0000)
RIGHTING LEVER AT GUST WIND OW2 = 0.366 M (COEFF. K2 = 1.5000)
ROLLING ANGLE = 38.82 DEG.

STABILITY AREA(A) 2.926 M-RAD. FROM-30.27 DEG. TO 0.81 DEG.
STABILITY AREA(B) 3.474 M-RAD. FROM 0.81 DEG. TO 72.89 DEG.
AREA RATIO C1= B/A = 1.187

** CHECK WRITE **

LATERAL WINDAGE AREA = 3367.08 SQ.M
LEVER OF WIND MOMENT = 9.658 M

ROLLING PERIOD T = 7.65 SEC. K= 18.701 M
REDUCTION COEFF N = 0.02740
GAMMA = 3.11956 P= 0.151
DELTA = 0.09589 Q= 0.007

** RIGHTING LEVER AND DYNAMICAL STABILITY CURVES

| INCLIN. ANGLE (DEG) | RIGHTING LEVER (M) | RIGHTING LEVER (GZ) IN (M) 0.0 / 5.0 / 10.0 | DYNAMICAL STABILITY (M-RAD) | DYNAMICAL STABILITY (MT-M) |
|---|---|---|---|---|
| 0.0 | 0.0 | | 0.0 | 0.0 |
| 5.00 | 2.323 | | 0.1039 | 1107.7 |
| 10.00 | 3.905 | | 0.3000 | 4051.3 |
| 12.00 | 4.345 | | 0.5742 | 5588.0 |
| 15.00 | 4.775 | | 0.7641 | 8147.2 |
| 20.00 | 5.023 | | 1.1941 | 12731.1 |
| 25.00 | 4.951 | | 1.6306 | 17385.2 |
| 30.00 | 4.684 | | 2.0521 | 21879.7 |
| 35.00 | 4.275 | | 2.4430 | 26055.6 |
| 40.00 | 3.772 | | 2.7954 | 29804.1 |
| 45.00 | 3.213 | | 3.1003 | 33055.2 |
| 50.00 | 2.631 | | 3.3552 | 35773.4 |
| 60.00 | 1.565 | | 3.7195 | 39656.8 |
| 70.00 | 0.644 | | 3.9118 | 41707.7 |
| 76.60 | 0.0 | | 0.0 | 0.0 |

COND 3 NORMAL BALL. JAPAN DEF.

** STABILITY STUDY FOR NO.2 CRITERION OF DEFENCE AGENCY

MAX.RIGHTING LEVER GZ1 = 5.026 M AT 20.63 DEG.

DISPLACEMENT D = 10662. MT
LATERAL WINDAGE AREA A = 3367.00 SQ.M
LEVER OF WIND MOMENT H = 9.658 M
WIND PRESSURE COEFF. K = 0.1900

RIGHTING LEVER COEFF. DW2 = 0.580 M

| INCLIN.ANGLE THETA (DEG) | COS(THITA) Q | DW2*Q*Q |
|---|---|---|
| 0.0 | 1.0000 | 0.580 |
| 5.00 | 0.9962 | 0.575 |
| 10.00 | 0.9848 | 0.562 |
| 12.00 | 0.9781 | 0.554 |
| 15.00 | 0.9659 | 0.541 |
| 20.00 | 0.9397 | 0.512 |
| 25.00 | 0.9063 | 0.476 |
| 30.00 | 0.8660 | 0.435 |
| 35.00 | 0.8192 | 0.389 |
| 40.00 | 0.7660 | 0.340 |
| 45.00 | 0.7071 | 0.290 |
| 50.00 | 0.6428 | 0.239 |
| 60.00 | 0.5000 | 0.145 |
| 70.00 | 0.3420 | 0.068 |
| 76.60 | 0.2318 | 0.031 |
| 90.00 | 0.0000 | 0.000 |
| 78.62 | 0.1973 | [illegible] |
| 90.00 | 0.0000 | 0.000 |

INTERSECTION BETWEEN GZ-CURVE AND DW2*Q*Q

GZ2 = 0.579 M AT 1.24 DEG.

RIGHTING LEVER RATIO C2 = GZ2/GZ1 = 0.115

復原性計算

| | |
|---|---|
| DISP | 25050.0 MT |
| DR AP | 7.880 M |
| DR FP | 4.970 M |
| KG0 | 8.680 M |
| GOM | 4.370 M |

BALLAST CONDITION

NORMAL

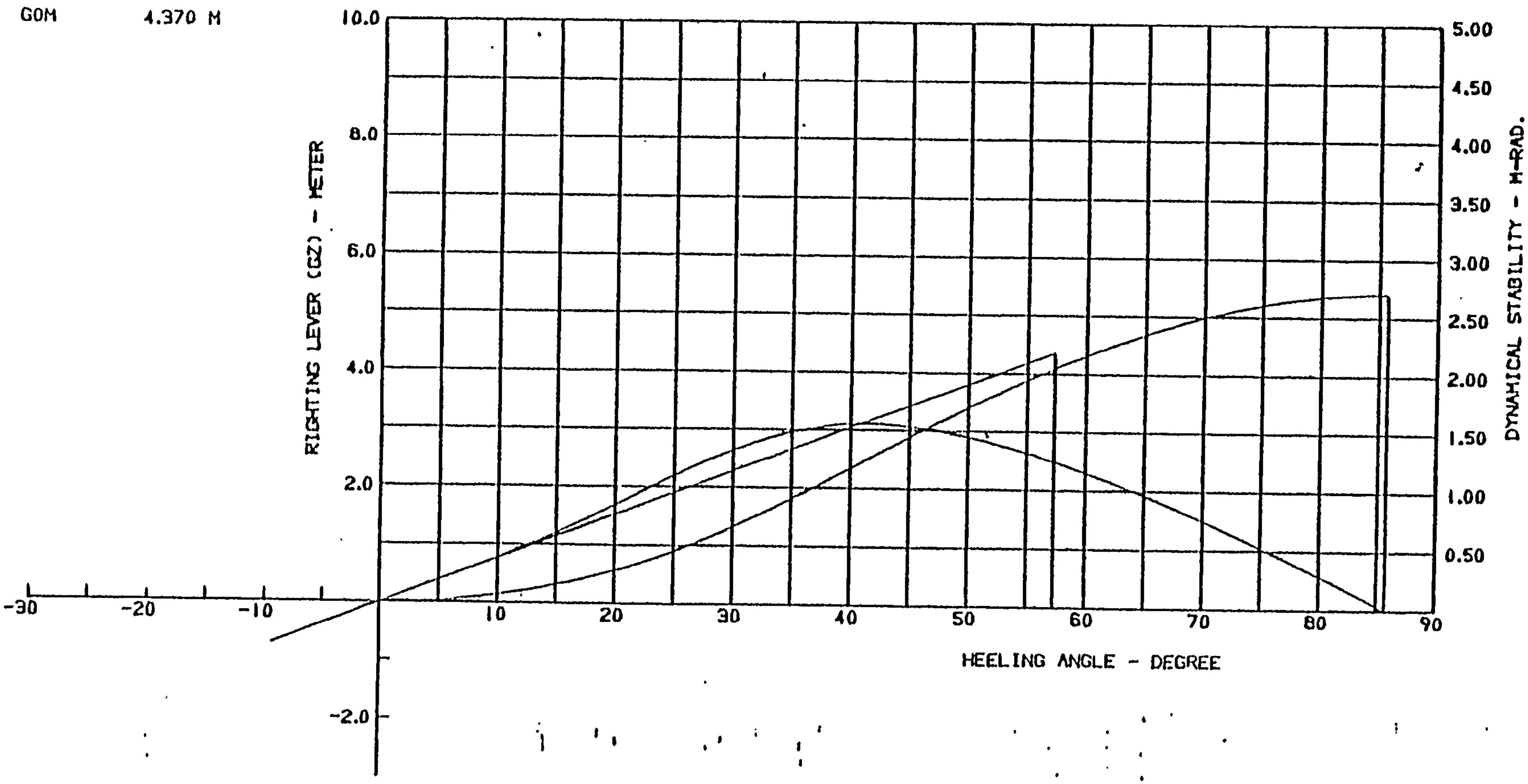
RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO e5.7 DEG.

MAX. RIGHTING LEVER - 3.112 M AT 40.7 DEG

FLOODING INTO MAIN HULL AT ANGLE - 63.6 DEG

DR AP 7.880 M
DR FP 4.970 M
KGO 8.680 M
GOM 4.370 M

FLOODING INTO MAIN HULL AT ANGLE = 63.6 DEG




復原性計算

CHECK STABILITY

SYOHI JYOTAI

| | | |
|---|---|---|
| DISP | 2950.3 | MT |
| OR AP | 3.990 | M |
| DR FP | I.610 | M |
| KG0 | 4.470 | M |
| GOM | 2.950 | M |

RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 OEG. TO 04.8 DEG.

MAX. RIGHTING LEVER - 1.658 M AT 40.0 DEG

| | | |
|---|---|---|
| DWI | 0.116 | M |
| DW2 | 0.175 | M |

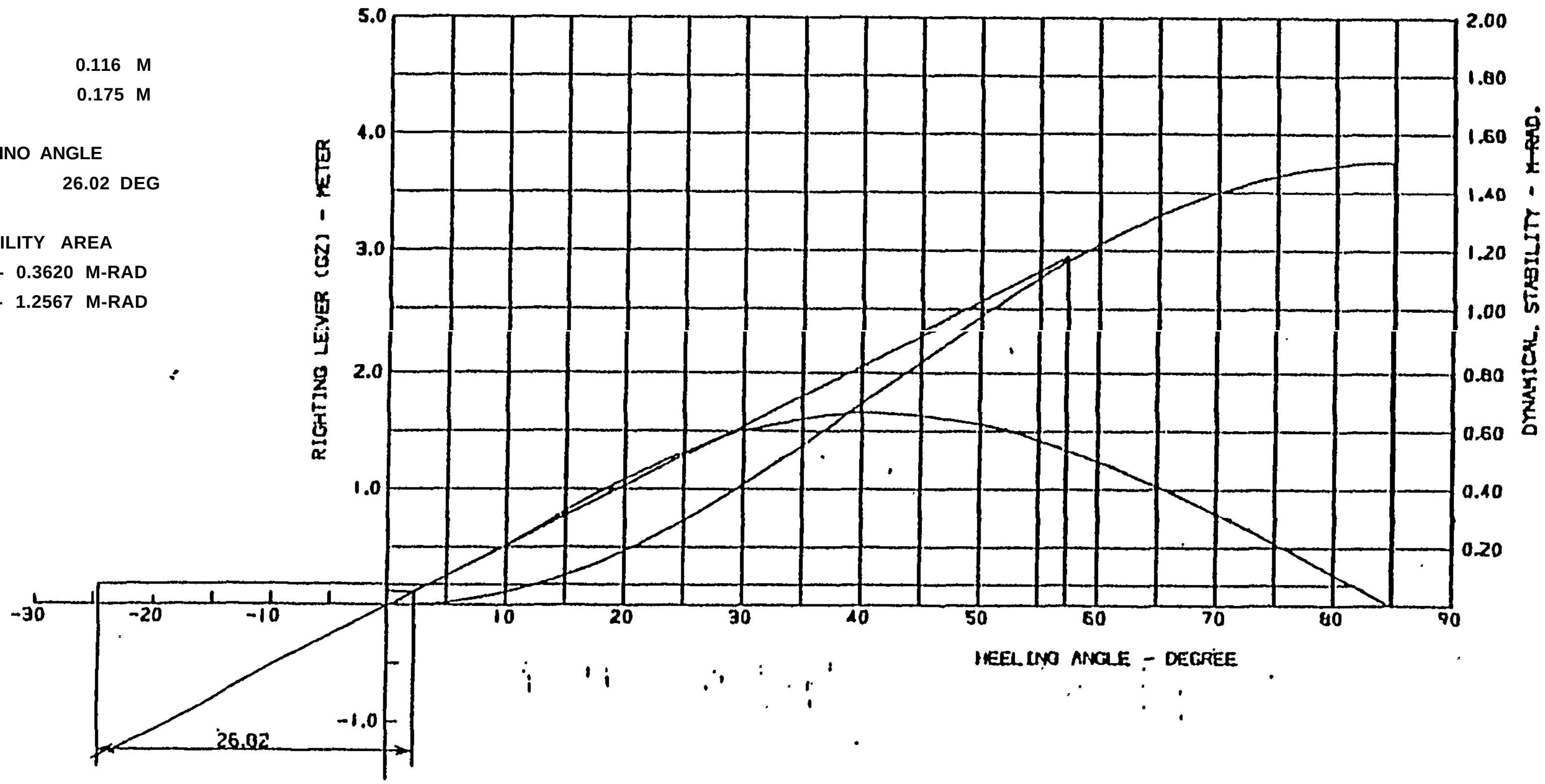
ROLLINO ANGLE

26.02 DEG

STADILITY AREA

A - 0.3620 M-RAD

B - 1.2567 M-RAD




復原性計算

```
** IN PUT DATA OF GRAIN STABILITY CALCULATION **

        TITLE                          : GRAIN STABILITY CALCULATION

        SIGN FOR UNIT                  :  0        0:METRIC        1:FEET

        SIGN FOR O/P COL. OF DISP.     :  0        0: **           1: **.*        2: **.**

        SIGN FOR PRINT OUT OF TABLE

            GRAIN STABILITY SUMMARY:      1        0:NOTHING       1:PRINT OUT

            ALLOWABLE HEELING MT.  :      2        0:NOTHING       1:PRINT OUT(CHANGE THE H.ANGLE)   2:PRINT OUT(CHAGE THE CONI

            HEELING MT. OF EACH SF :      1        0:NOTHING       1:PRINT OUT

        SIGN FOR RULE          IMCO :  264

        SIGN FOR CALCULATION METHOD

            STABILITY CALCULATION  :      3

            HEELING MT.            :      0        0:LOADED LEVEL 1:MAX.MT.

            GZ CROSS CURVE         :      0        0:FREE          1:UNDER UPP.DK 2:INCLUDE SUP.STRUC.
```

TABLE OF TRANSVERSE HEELING MOMENT FOR GRAIN.FILLED LOADED (HEELING ANGLE 15.0 DEG.)

| CARGO HOLD | VOL. HEELING MOMENT (M **4) | 40.0000 | 41.0000 | 42.0000 |
| --- | --- | --- | --- | --- |
| | | STOWAGE FACTOR (CUB.FT/LT) | | |
| | | TRANSVERSE HEELING MOMENT (MT-M) | | |
| NO.1 CARGO HOLD | 1022 | 917 | 894 | 873 |
| NO.2 CARGO HOLD | 1131 | 1015 | 990 | 966 |
| NO.3 CARGO HOLD | 973 | 873 | 852 | 832 |
| NO.4 CARGO HOLD | 1059 | 950 | 927 | 905 |
| NO.5 CARGO HOLD | 1132 | 1016 | 991 | 967 |
| TOTAL | 5317 | 4771 | 4654 | 4543 |

TABLE OF VERTICAL SHIFTING MOMENT FOR GRAIN FILLED LOADED (HEELING ANGLE 15.0 DEG.)

| CARGO HOLD | VOL. HEELING MOMENT (M **4) | 40.0000 | 41.0000 | 42.0000 |
| --- | --- | --- | --- | --- |
| | | STOWAGE FACTOR (CUB.FT/LT) | | |
| | | VERTICAL SHIFTING MOMENT (MT-M) | | |
| NO.1 CARGO HOLD | 100 | 90 | 88 | 86 |
| NO.2 CARGO HOLD | 112 | 101 | 98 | 96 |
| NO.3 CARGO HOLD | 124 | 111 | 109 | 106 |
| NO.4 CARGO HOLD | 105 | 94 | 92 | 89 |
| NO.5 CARGO HOLD | 113 | 101 | 99 | 96 |
| TOTAL | 554 | 497 | 486 | 473 |

TABLE OF ALLOWABLE HEELING MOMENT

| DISPT (MT) | MIN. GOM (M) | MIN. HEEL. MT (MT-M) | GOM (M) 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 | 1.00 | 1.10 | CHECK LIST RESID. S.AREA (M-RAD) | HEEL. ANGLE (DEG) | EFFEC. RANGE (DEG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALLOWABLE HEELING MOMENT (MT-M) | | | | | | | | | | | |
| 55000 | 0.30 | 6260 | 6260 | 7477 | 8693 | 9910 | 11126 | 12343 | 13559 | 14776 | 15992 | 0.145 | 12.0 | 35.0 |
| 56000 | 0.30 | 6326 | 6326 | 7565 | 8803 | 10042 | 11280 | 12519 | 13758 | 14996 | 16235 | 0.140 | 12.0 | 35.0 |
| 57000 | 0.30 | 6399 | 6399 | 7660 | 8921 | 10181 | 11442 | 12703 | 13964 | 15224 | 16485 | 0.135 | 12.0 | 35.0 |
| 58000 | 0.30 | 6490 | 6490 | 7773 | 9056 | 10339 | 11622 | 12905 | 14187 | 15470 | 16753 | 0.129 | 12.0 | 35.0 |
| 59000 | 0.30 | 6577 | 6577 | 7882 | 9187 | 10492 | 11797 | 13102 | 14407 | 15712 | 17017 | 0.123 | 12.0 | 35.0 |
| 60000 | 0.30 | 6662 | 6662 | 7989 | 9316 | 10643 | 11970 | 13297 | 14624 | 15951 | 17278 | 0.113 | 12.0 | 34.6 |
| 61000 | 0.30 | 6745 | 6745 | 8094 | 9443 | 10793 | 12142 | 13491 | 14840 | 16189 | 17539 | 0.100 | 12.0 | 33.7 |
| 62000 | 0.30 | 6832 | 6832 | 8204 | 9575 | 10946 | 12318 | 13689 | 15060 | 16432 | 17803 | 0.085 | 12.0 | 32.4 |
| 63000 | 0.34 | 7397 | 6874 | 8268 | 9661 | 11055 | 12448 | 13842 | 15235 | 16629 | 18022 | 0.075 | 12.0 | 31.4 |
| 64000 | 0.47 | 9385 | 6981 | 8397 | 9812 | 11228 | 12644 | 14059 | 15475 | 16890 | 18306 | 0.075 | 12.0 | 30.9 |
| 65000 | 0.61 | 11395 | 6991 | 8429 | 9866 | 11304 | 12742 | 14179 | 15617 | 17055 | 18492 | 0.075 | 12.0 | 30.4 |
| 66000 | 0.73 | 13473 | 7178 | 8638 | 10098 | 11558 | 13017 | 14477 | 15937 | 17397 | 18857 | 0.075 | 12.0 | 30.1 |
| 66500 | 0.78 | 14361 | 7235 | 8765 | 10176 | 11647 | 13118 | 14589 | 16060 | 17531 | 19002 | 0.075 | 12.0 | 30.1 |
| 67000 | 0.87 | 15781 | 7287 | 8768 | 10250 | 11732 | 13214 | 14696 | 16178 | 17660 | 19142 | 0.075 | 12.0 | 29.7 |
| 67500 | 0.94 | 16941 | 7350 | 8843 | 10336 | 11829 | 13322 | 14815 | 16308 | 17801 | 19294 | 0.075 | 12.0 | 29.6 |
| 68000 | 1.02 | 18276 | 7406 | 8910 | 10414 | 11918 | 13422 | 14926 | 16430 | 17934 | 19438 | 0.075 | 12.0 | 29.4 |
| 68500 | 1.11 | 19722 | 7460 | 8975 | 10490 | 12005 | 13520 | 15035 | 16551 | 18066 | 19581 | 0.075 | 12.0 | 29.1 |

REMARK GOM : CORRECTED GM WITH GGO

(3-2) HOMO. FULL D=10.753 S.V. ARR.

PARTICULAR OF STABILITY

| | THIS SHIP | | CRITERIA IMCO |
|---|---|---|---|
| DISPLACEMENT | 44736 MT | 44029 LT | — |
| CORRECTED GM | 2.510 M | 8.235 FT | 0.3 M |
| RESIDUAL STABILITY AREA | 0.475 M-RAD. | 1.562 FT-RAD. | 0.075 M-RAD. |
| HEELING ANGLE | 2.9 DEG. | | 12.0 DEG. |
| ACTUAL HEELING MOMENT | 3756 MT-M | 13586 LT-FT | — |
| MAX. RIGHTING LEVER | 1.392 M | 4.567 FT | — |
| MAX. RIGHTING LEVER AT ANGLE | 37.6 DEG. | | — |
| ANGLE OF FLOODING | 44.5 DEG. | | — |
| RANGE OF RESIDUAL AREA | 37.6 DEG. | | — |
| RAMDA 0 | 0.129 M | 0.423 FT | — |
| ALLOWABLE HEELING MOMENT | 26283 MT-M | 84868 LT-FT | — |

*** CHECK LIST ***

A : AREA BETWEEN 0.0 DEG. AND 30.0 DEG.

0.369 M-RAD. 1.211 FT-RAD.

B : AREA BETWEEN 0.0 DEG. AND 40.0 DEG.

0.608 M-RAD. 1.995 FT-RAD.

C : AREA BETWEEN 30.0 DEG.(A) AND 40.0 DEG.(B)

0.239 M-RAD. 0.784 FT-RAD.

| INCLIN. ANGLE (DEG.) | RIGHTING LEVER (M) | STATICAL RIGHTING LEVER (M) 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 |
|---|---|---|
| 0.0 | 0.0 | I* |
| 5.00 | 0.221 | I * |
| 10.00 | 0.453 | I |
| 15.00 | 0.748 | I * |
| 20.00 | 0.992 | I * |
| 25.00 | 1.191 | I * |
| 30.00 | 1.313 | I * |
| 35.00 | 1.380 | I * |
| 40.00 | 1.389 | I * |
| 44.52 | 1.345 | I * ← |
| 44.52 | 0.0 | I* ← INFLOW POINT |

SUMMARY TABLE OF GRAIN STABILITY CALCULATION

| CONDITIONS | | GRAIN LOAD (S.F.= 50) | GRAIN LOAD (S.F.= 50) | GRAIN LOAD (S.F.= 55) | GRAIN LOAD (S.F.= 55) |
|---|---|---|---|---|---|
| (ITEM) | (UNITS) | VANCOUVER DEP. | JAPAN ARR. | VANCOUVER DEP. | JAPAN ARR. |
| S.G. OF SEA WATER | (MT/CUB.M ) | 1.0250 | 1.0250 | 1.0250 | 1.0250 |
| STOWAGE FACTOR | (CUB.FT/LT) | 50.0000 | 50.0000 | 55.0000 | 55.0000 |
| DISPLACEMENT | ( MT ) | 59759 | 59355 | 56137 | 55813 |
| CORRESPONDING DRAFT | ( M ) | 11.38 | 11.31 | 10.73 | 10.68 |
| L C G | ( M ) | -6.41 | -6.45 | -6.65 | -6.67 |
| L C B | ( M ) | -6.06 | -6.09 | -6.33 | -6.35 |
| M T C | (MT-M ) | 734.6 | 732.7 | 717.8 | 716.3 |
| TRIM | ( M ) | -0.28 | -0.29 | -0.25 | -0.25 |
| L C F | ( M ) | -1.49 | -1.58 | -2.23 | -2.30 |
| DRAFT AT FP | ( M ) | 11.52 | 11.45 | 10.86 | 10.80 |
| AT AP | ( M ) | 11.24 | 11.16 | 10.61 | 10.55 |
| AT MID. | ( M ) | 11.38 | 11.30 | 10.73 | 10.67 |
| T.KM | ( M ) | 13.05 | 13.06 | 13.12 | 13.13 |
| K G | ( M ) | 10.33 | 10.44 | 10.36 | 10.49 |
| GGO | ( M ) | 0.18 | 0.17 | 0.22 | 0.23 |
| GOM | ( M ) | 2.54 | 2.45 | 2.54 | 2.41 |
| HEELING MT. TO 1 DEG. | (MT-M ) | 2650.0 | 2539.0 | 2490.0 | 2349.0 |
| ACTUAL HEELING MT. | (MT-M ) | 5474 | 5474 | 4977 | 4977 |
| ALLOWABLE HEELING MT. | (MT-M ) | 36031 | 34617 | 33949 | 32163 |
| HEELING ANGLE | (DEG.) | 2.0 | 2.1 | 2.0 | 2.1 |
| RESIDUAL STABILITY AREA | (M -RAD.) | 0.689 | 0.670 | 0.726 | 0.698 |
| ANGLE OF FLOODING | (DEG.) | 49.8 | 50.1 | 52.2 | 52.4 |
| MAX. RIGHTING LEVER | ( M ) | 2.00 | 1.96 | 2.18 | 2.11 |

ASSUMED AND REAL GZ VALUES AT 12 DEG. AND 40 DEG.
OF EACH CONDITION

ASSUMED KG = 11.000(M )

| CONDITION NAME | DISPT (MT) | STOWAGE FACTOR (CUB.FT /LT) | GZ VALUES (M ) ASSUMED GZ 12 DEG. | ASSUMED GZ 40 DEG. | REAL GZ 12 DEG. | REAL GZ 40 DEG. |
|---|---|---|---|---|---|---|
| GRAIN LOAD (S.F.= 40) VANCOUVIR DEP. | 70965 | 40.0000 | 0.479 | 0.998 | 0.608 | 1.397 |
| | 0 | 0.0000 | 0.000 | 0.000 | 0.000 | 0.000 |

FILLED COMP の HEELING ANGLE を示す
(* 印のない COMP. を示す.)

TABLE OF ACTUAL TRANSVERSE HEELING MOMENT OF EACH CONDITION (HEELING ANGLE 15.0 DEG.)
(UNITS : MT-M )

| CARGO HOLD | COND.NAME VOL. HEELING MOMENT (M **4) | GRAIN LOAD (S.F.= 40) VANCOUVER DEP. | | GRAIN LOAD (S.F.= 42) VANCOUVER DEP. | GRAIN LOAD (S.F.= 42) JAPAN ARR. | GRT LOAD (ALTERNATE) JAPAN ARR. |
|---|---|---|---|---|---|---|
| NO.1 CARGO HOLD | 1022 | 3415 | 0 | 873 | 873 | 4207 |
| | | * 3007 | 0 | 1022 | 1022 | * 2630 |
| NO.2 CARGO HOLD | 1131 | 1015 | 0 | 966 | 966 | 0 |
| | | 1131 | 0 | 1131 | 1131 | 0 |
| NO.3 CARGO HOLD | 973 | 873 | 0 | 832 | 832 | 1557 |
| | | 973 | 0 | 973 | 973 | 973 |
| NO.4 CARGO HOLD | 1059 | 950 | 0 | 905 | 905 | 0 |
| | | 1059 | 0 | 1059 | 1059 | 0 |
| NO.5 CARGO HOLD | 1132 | 1016 | 0 | 967 | 967 | 1011 |
| | | 1132 | 0 | 1132 | 1132 | 1132 |
| NO.6 CARGO HOLD | 1132 | 1016 | 0 | 967 | 967 | 0 |
| | | 1132 | 0 | 1132 | 1132 | 0 |
| NO.7 CARGO HOLD | 1178 | 1057 | 0 | 1007 | 1007 | 1530 |
| | | 1178 | 0 | 1178 | 1178 | * 958 |
| TOTAL | 7627 | 9342 | 0 | 6517 | 6517 | 9105 |

各HOLD共
上段 HEELING MT.
下段 VOL. HEELING MT.

REMARK :
* ... PARTLY FILLED COMPARTMENT (HEELING ANGLE 25.0 DEG.)
HEELING MOMENT =1.12*(CALCULATED HEELING MOMENT)

(B-1) HOMO. FULL D-10.763 S.V. DEP.

DISP. 45321.0 MT
CRAP 10.766 M
DRFP 10.766 M
KGO 9.070 M
GOM 2.440 M

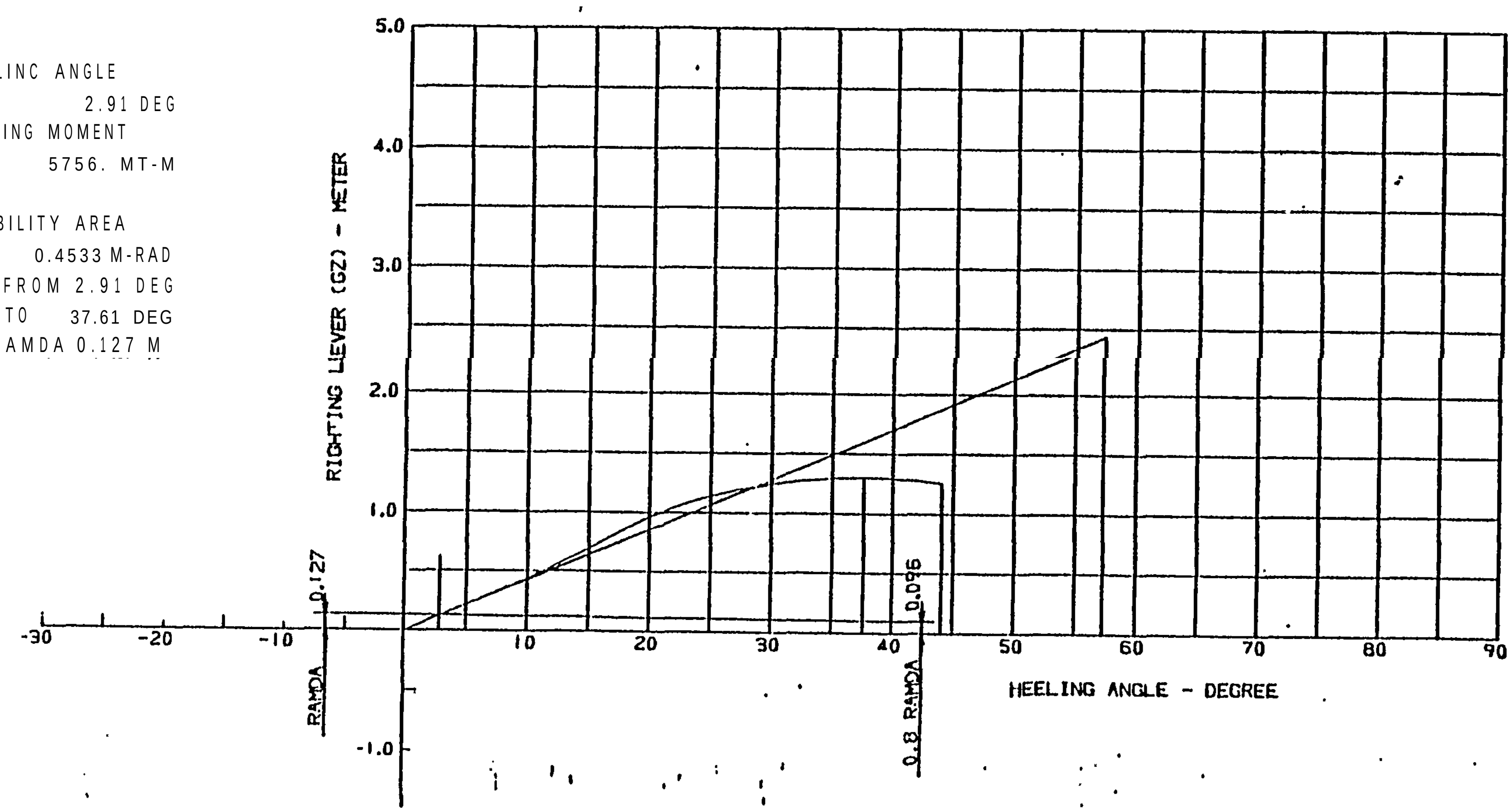
RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 44.0 DEG.

MAX. RIGHTING LEVER - 1.299 M AT 37.6 DEG

FLOODING INTO MAIN HULL AT ANGLE - 44.0 DEG

HEELINC ANGLE
2.91 DEG
HEELING MOMENT
5756. MT-M

STABILITY AREA
0.4533 M-RAD
FROM 2.91 DEG
TO 37.61 DEG
AT RAMDA 0.127 M




GRAIN STABILITY

CON 1 FULL LOAD CONDITION AT P.G. PEP. ROUND TANKER

DAMAGED FLOODING CALCULATION .... IN FINAL STAGE

(1) INITIAL CONDITION

| | | | |
|---|---|---|---|
| DISPLACEMENT | 298785.0 (M) | LCG | -10.010 (M) |
| | | TCG | 0.0 (M) |
| DRAFT AT FP | 20.004 (M) | KG | 14.070 (M) |
| DRAFT AT AP | 20.374 (M) | | |
| DRAFT (MEAN) | 20.189 (M) | | |
| | | HEEL (DEGREE) | 0.0 |
| TRIM | 0.370 (M) | (TANGENT) | 0.0 |

(2) FLOODED COMPARTMENT NAME AND THEIR WEIGHT

| NO | FLOODED COMPARTMENT | PERMEA-BILITY | WEIGHT (MT) | LCG (M) | TCG (M) | KG (M) |
|---|---|---|---|---|---|---|
| 13 | NO. 3 W.B.T. (C) | 1.000 | 29552.7 | -18.135 | 0.000 | 11.030 |

(3) FLOODED FINAL CONDITION

| | DISPLACEMENT (MT) | LCB (M) | TCB (M) | KB (M) |
|---|---|---|---|---|
| MAIN HULL | 328341.4 | -10.751 | 0.000 | 11.303 |
| FLOODED SUM (-) | 29552.7 | -18.135 | 0.000 | 11.030 |
| RESULTANT TOTAL | 298788.7 | -10.021 | 0.000 | 11.417 |

| | | | |
|---|---|---|---|
| DRAFT AT FP | 22.399 (M) | TONS PER 1 CM IMM. | 148.666 (MT) |
| DRAFT AT AP | 21.670 (M) | TRANSVERSE GOM | 8.172 (M) |
| DRAFT (MEAN) | 22.035 (M) | LONGITUDINAL GOM | 391.813 (M) |
| TRIM | -0.730 (M) | LOWEST INFLOW POINT | |
| | | FRAME NO. 56 DIFF. | 0.0 (M) |
| HEEL (DEGREE) | 0.000 | BREADTH | 0.0 (M) |
| (TANGENT) | 0.000 | HEIGHT ABOVE BL | 27.903 (M) |
| | | HEIGHT ABOVE WL | 6.125 (M) |

CON 1 FULL LOAD CONDITION AT P.G. PEP. ROUND BANKER

RELATIONS BETWEEN WATER LINE AND DECK SIDE LINE IN FINAL STAGE

| NO | STATION | DISTANCE FROM AP (M) | DRAFT AT CL (M) | HEIGHT FROM WL TO DK CL (M) | DRAFT AT SL (M) | HEIGHT FROM WL TO DK SL (M) |
|---|---|---|---|---|---|---|
| 1 | -0.258 | -8.250 | 21.651 | 6.252 | 21.651 | 6.252 |
| 2 | 0.0 | 0.0 | 21.670 | 6.223 | 21.670 | 6.064 |
| 3 | 0.500 | 16.000 | 21.706 | 6.197 | 21.706 | 5.672 |
| 4 | 1.000 | 32.000 | 21.743 | 6.160 | 21.743 | 5.437 |
| 5 | 1.500 | 48.000 | 21.779 | 6.124 | 21.779 | 5.290 |
| 6 | 2.000 | 64.000 | 21.816 | 6.087 | 21.816 | 5.197 |
| 7 | 2.500 | 80.000 | 21.852 | 6.051 | 21.852 | 5.148 |
| 8 | 3.000 | 96.000 | 21.889 | 6.014 | 21.889 | 5.111 |
| 9 | 3.500 | 112.000 | 21.925 | 5.978 | 21.925 | 5.075 |
| 10 | 4.000 | 128.000 | 21.962 | 5.941 | 21.962 | 5.038 |
| 11 | 4.500 | 144.000 | 21.998 | 5.905 | 21.998 | 5.002 |
| 12 | 5.000 | 160.000 | 22.035 | 5.868 | 22.035 | 4.965 |
| 13 | 5.500 | 176.000 | 22.071 | 5.832 | 22.071 | 4.929 |
| 14 | 6.000 | 192.000 | 22.108 | 5.795 | 22.108 | 4.892 |
| 15 | 6.500 | 208.000 | 22.144 | 5.759 | 22.144 | 4.856 |
| 16 | 7.000 | 224.000 | 22.180 | 5.723 | 22.181 | 4.819 |
| 17 | 7.500 | 240.000 | 22.217 | 5.686 | 22.217 | 4.783 |
| 18 | 8.000 | 256.000 | 22.253 | 5.650 | 22.254 | 4.746 |
| 19 | 8.500 | 272.000 | 22.290 | 5.613 | 22.290 | 4.738 |
| 20 | 9.000 | 288.000 | 22.326 | 5.866 | 22.326 | 5.131 |
| 21 | 9.500 | 304.000 | 22.363 | 7.060 | 22.363 | 6.568 |
| 22 | 10.000 | 320.000 | 22.399 | 8.256 | 22.399 | 8.147 |

ANGLE AT WHICH DECK EDGE COINCIDES WITH WATER LINE 10.010 DEG.
ABOVE POSITION STATION 8.401 (268.840 (M) FROM AP)

RELATIONS BETWEEN WATER LINE AND INFLOW POINT IN FINAL STAGE

| NO | INFLOW POINTS FR.NO. | DIFF. (M) | BREADTH (M) | HEIGHT (M) | HEIGHT FROM WL TO INFLOW POINT (M) | ANGLE AT WHICH I.P. COINCIDES WITH WL (DEG) |
|---|---|---|---|---|---|---|
| 1 | 56.000 | 0.0 | 0.0 | 27.903 | 6.125 | 90.000 |
| 2 | 20.000 | 0.0 | 20.000 | 28.500 | 6.796 | 18.768 |
| 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

COND 1 HEEL CHECK FOR FLOOD. CAL.

** PARTICULARS FOR STABILITY

DISPLACEMENT 35600. MT DRAFT AT AP 10.809 M
DRAFT AT FP 10.809 M
CORRECTED KG (KGO) 10.240 M
CORRECTED GM (GOM) 10.560 M

** RIGHTING LEVER (GZ) CURVE INFORMATION

RANGE OF POSITIVE RIGHTING LEVER FROM 16.91 DEG. TO 98.91 DEG.
MAX.RIGHTING LEVER. 2.876 M AT 40.67 DEG.
ANGLE OF FLOODING INTO MAIN HULL NOTHING

** STABILITY STUDY AT FINAL STAGE AFTER FLOODING

RIGHTING LEVER AT STEADY WIND DH3 = 0.004 M (COEFF. K3 = 0.0153)
RIGHTING LEVER AT GUST WIND DH4 = 0.007 M (COEFF. K4 = 1.5000)
ROLLING ANGLE = 0.0 DEG.

STABILITY AREA(A) 0.000 M-RAD. FROM 16.94 DEG. TO 16.95 DEG.
STABILITY AREA(B) 2.360 M-RAD. FROM 16.95 DEG. TO 98.79 DEG.
AREA RATIO C3= B/A = 0.0

** CHECK WRITE **

LATERAL WINDAGE AREA = 1056.94 SQ.M
LEVER OF WIND MOMENT = 10.000 M

** RIGHTING LEVER AND DYNAMICAL STABILITY CURVES

| INCLIN. ANGLE (DEG) | RIGHTING LEVER (M) | RIGHTING LEVER (GZ) IN (M) 0.0 2.0 4.0 | DYNAMICAL STABILITY (M-RAD) | DYNAMICAL STABILITY (MT-M) |
|---|---|---|---|---|
| 0.0 | -2.443 | | 0.0 | 0.0 |
| 5.00 | -1.781 | | 0.0 | 0.0 |
| 10.00 | -1.079 | | 0.0 | 0.0 |
| 15.00 | -0.316 | | 0.0 | 0.0 |
| 20.00 | 0.537 | | 0.0141 | 500.3 |
| 25.00 | 1.497 | | 0.1031 | 3671.6 |
| 30.00 | 2.276 | | 0.2695 | 9595.4 |
| 35.00 | 2.725 | | 0.4899 | 17441.5 |
| 40.00 | 2.874 | | 0.7354 | 26178.8 |
| 45.00 | 2.837 | | 0.9853 | 35075.2 |
| 50.00 | 2.677 | | 1.2264 | 43660.4 |
| 60.00 | 2.130 | | 1.6458 | 58592.1 |
| 90.91 | 0.0 | | 0.0 | 0.0 |

損傷時復原性計算

損傷時復原性計算

HEAVY BALL. FULL BUNKER DEPARTURE

DISP. 33199.6 MT
DR AP 8.792 M
DR FP 8.218 M
KG0 8.227 M
GOM 3.866 M

DWI 0.033 M
DW2 0.049 M

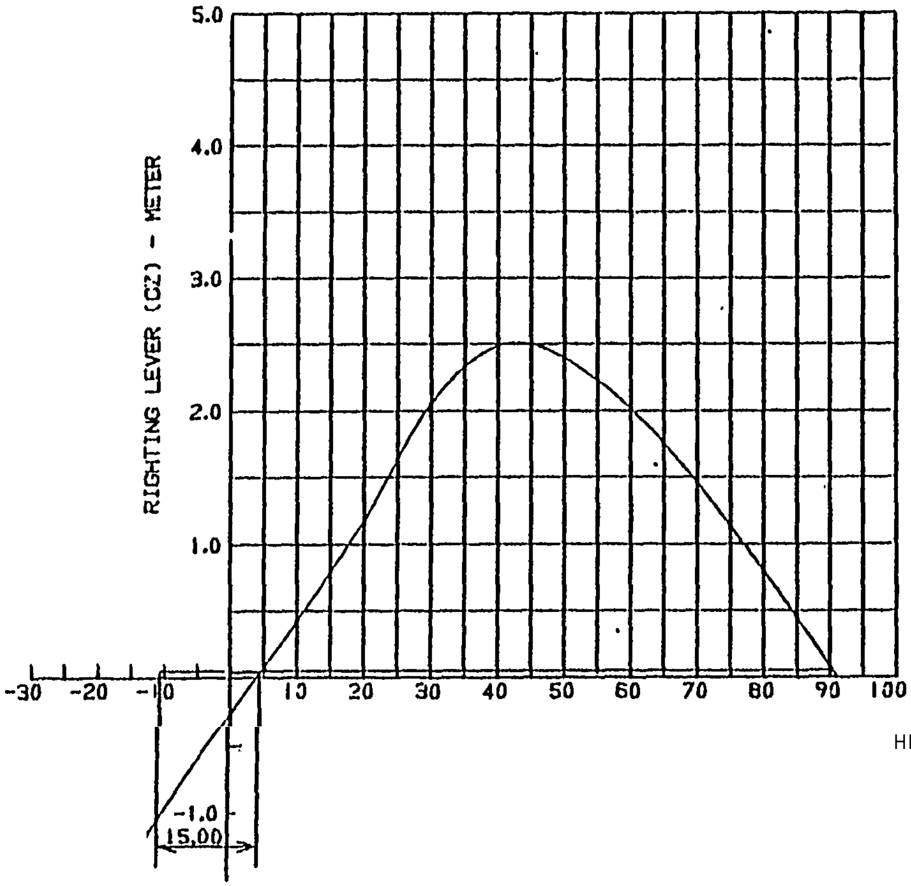
ROLLING ANGLE
I5.00 DEG

STABILITY AREA
A " 0.1423 M-RAD
B - 2.1745 M-RAD

RANGE OF POSITIVE RIGHTING LEVER FROM 3.9 DEG. TO 91.1 DEG.

MAX. RIGHTING LEVER 2.499 M AT 42.1 DEG

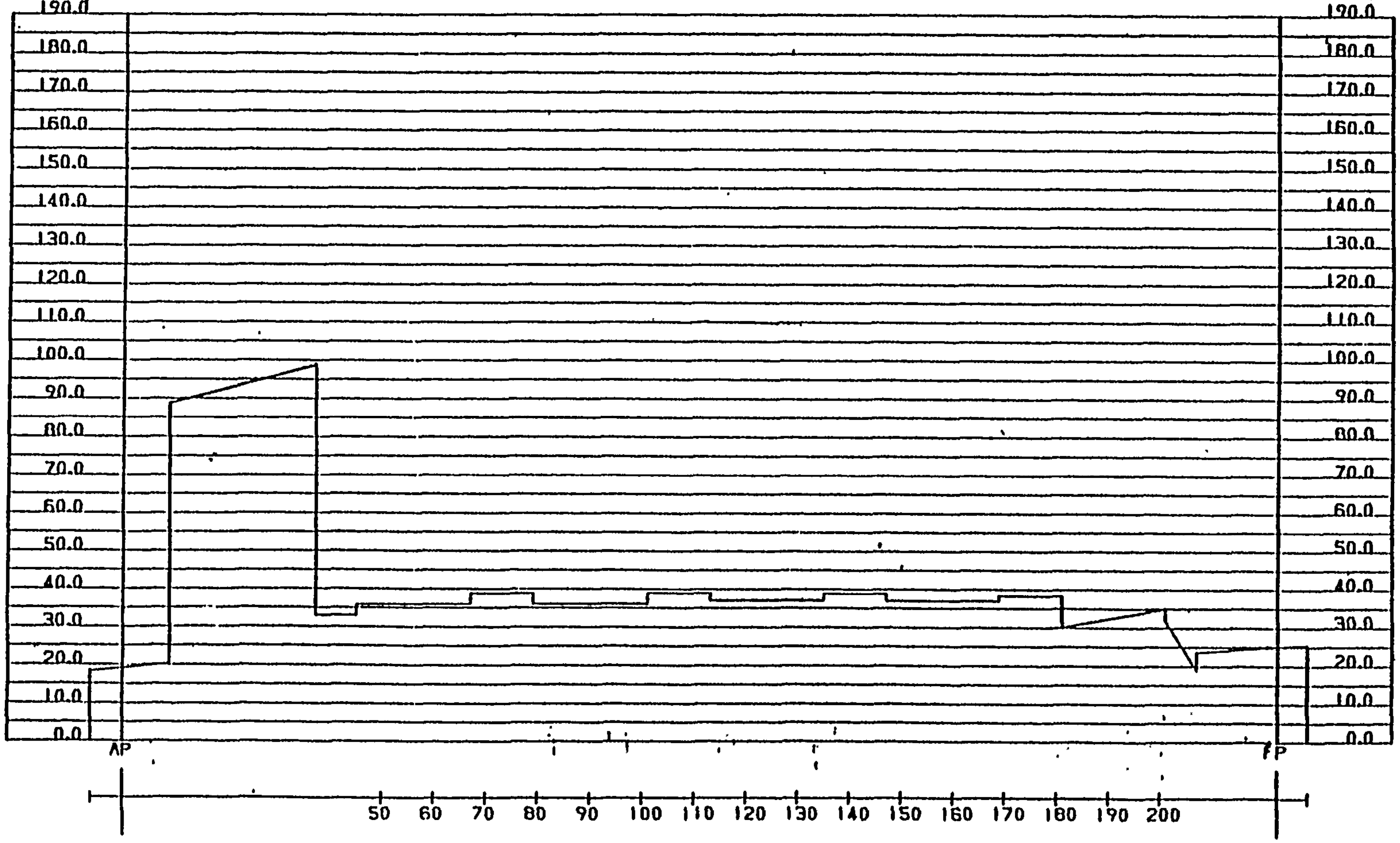
FLOODING INTO MAIN HULL AT ANGLE - 57.5 DEG




HEELING ANGLE - DEGREE

## SNO. LIGHT WEIGHT DISTRIBUTION CURVE

| | | | |
|---|---|---|---|
| TOTAL LIGHT WEIGHT = | **7644.00** M.TON | LENGTH O.A. | 187.730 M |
| G = | 12.420 METER | LENGTH B.P | 178.000 M |
| KO = | 9.130 METER | BREADTH (MLD) | 28.400 M |
| | | DEPTH (MLD) | 15.300 M |




L/W 分布

COND 1 FULL LOAD CONDITION AT P.G. PEP. ROUND BANKER
STILL WATER CONDITION
WAVE LENGTH = 0.0 M HEIGHT = 0.0 M CREST = 0.0 M FROM AP
DEADWEIGHT = 261120.MT DRAFT AT AP = 20.5664
DISPLACEMENT = 299780.MT DRAFT AT FP = 19.8944
SPECIFIC G = 1.0250
DWN MAX SF = -8560.MT AT 166.300M FROM AP +MEANS UPPDOWN SF
UPP MAX SF = 8777.MT AT 209.900M FROM AP -MEANS DOWNUPP SF
SAG MAX BM = 244024.MT-M AT 273.420M FROM AP +MEANS SAGGING BM
HOG MAX BM = -96599.MT-M AT 177.479M FROM AP -MEANS HOGGING BM

| CAL. NO | POINT FRNO | DIFF | DISTANCE FROM AP | DRAFT (M) | TOTAL WEIGHT (LEFT) | TOTAL WEIGHT (RIGHT) | BUOYANCY (SQ.M) | SF (MT) | BM (MT-M) | DEFLECTION (SF/M) | DEFLECTION (BM/M) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -11 | 0.250 | -8.060 | 20.514 | 0.0 | 54.063 | 0.0 | 0. | 0. | -0.001 | 0.006 | 0.005 |
| 2 | -10 | 0.0 | -7.500 | 20.515 | 54.768 | 54.768 | 1.426 | -27. | -7. | -0.001 | 0.005 | 0.004 |
| 3 | -9 | 0.001 | -6.749 | 20.513 | 55.826 | 55.826 | 8.967 | -65. | -42. | -0.001 | 0.005 | 0.004 |
| 4 | -9 | 0.350 | -6.400 | 20.513 | 56.317 | 56.317 | 12.355 | -81. | -67. | -0.001 | 0.005 | 0.004 |
| 5 | -7 | -0.001 | -5.251 | 20.510 | 57.893 | 57.893 | 22.758 | -125. | -186. | -0.001 | 0.004 | 0.003 |
| 6 | -5 | -0.250 | -4.500 | 20.508 | 59.639 | 59.639 | 32.444 | -163. | -368. | -0.000 | 0.003 | 0.002 |
| 7 | -5 | -0.000 | -3.750 | 20.507 | 59.960 | 59.960 | 34.273 | -170. | -416. | -0.000 | 0.003 | 0.002 |
| 8 | -3 | 0.375 | -1.875 | 20.504 | 62.429 | 62.429 | 46.930 | -206. | -766. | -0.000 | 0.001 | 0.001 |
| 9 | -2 | -0.100 | -1.600 | 20.503 | 62.794 | 62.794 | 48.726 | -210. | -823. | -0.000 | 0.001 | 0.001 |
| 10 | 0 | 0.0 | 0.0 | 20.500 | 64.858 | 64.858 | 58.866 | -224. | -1172. | 0.0 | 0.0 | 0.0 |
| 11 | 2 | -0.250 | 1.250 | 20.498 | 66.430 | 66.430 | 66.217 | -226. | -1454. | 0.000 | -0.001 | -0.001 |
| 12 | 2 | 0.0 | 1.500 | 20.498 | 66.746 | 66.746 | 67.693 | -225. | -1510. | 0.000 | -0.001 | -0.001 |
| 13 | 3 | 0.0 | 2.250 | 20.496 | 67.672 | 67.672 | 72.219 | -222. | -1678. | 0.000 | -0.002 | -0.001 |
| 14 | 4 | 0.200 | 3.200 | 20.494 | 68.845 | 68.845 | 78.396 | -213. | -1885. | 0.000 | -0.002 | -0.002 |
| 15 | 5 | 0.250 | 4.000 | 20.493 | 69.806 | 69.806 | 83.923 | -203. | -2052. | 0.000 | -0.003 | -0.003 |
| 16 | 6 | 0.0 | 4.500 | 20.492 | 70.406 | 102.372 | 88.129 | -194. | -2151. | 0.000 | -0.003 | -0.003 |
| 17 | 6 | 0.300 | 4.800 | 20.491 | 104.270 | 104.270 | 90.766 | -197. | -2210. | 0.000 | -0.003 | -0.003 |
| 18 | 9 | -0.350 | 6.400 | 20.488 | 109.037 | 109.367 | 106.284 | -217. | -2535. | 0.000 | -0.005 | -0.004 |
| 19 | 10 | 0.0 | 7.500 | 20.486 | 112.231 | 112.231 | 118.269 | -202. | -2760. | 0.000 | -0.005 | -0.005 |
| 20 | 11 | -0.250 | 8.000 | 20.485 | 113.697 | 113.697 | 124.244 | -196. | -2860. | 0.000 | -0.006 | -0.005 |
| 21 | 14 | 0.0 | 10.500 | 20.480 | 120.931 | 96.302 | 165.275 | -122. | -3273. | 0.001 | -0.008 | -0.007 |
| 22 | 16 | 0.0 | 12.000 | 20.478 | 102.078 | 102.078 | 192.151 | 4. | -3267. | 0.001 | -0.009 | -0.008 |
| 23 | 17 | 0.0 | 12.750 | 20.476 | 124.925 | 165.911 | 204.781 | 79. | -3336. | 0.001 | -0.009 | -0.009 |
| 24 | 17 | 0.050 | 12.800 | 20.476 | 166.254 | 166.254 | 205.621 | 81. | -3337. | 0.001 | -0.010 | -0.009 |
| 25 | 20 | 0.0 | 15.000 | 20.472 | 181.282 | 203.574 | 242.373 | 204. | -3078. | 0.000 | -0.011 | -0.011 |
| 26 | 21 | 0.100 | 16.000 | 20.470 | 210.360 | 210.360 | 258.936 | 254. | -2860. | 0.000 | -0.012 | -0.011 |
| 27 | 23 | -0.100 | 17.600 | 20.467 | 221.218 | 221.218 | 285.280 | 355. | -2317. | 0.000 | -0.013 | -0.013 |
| 28 | 25 | -0.300 | 19.200 | 20.464 | 232.014 | 232.014 | 311.364 | 402. | -1651. | 0.000 | -0.014 | -0.014 |
| 29 | 25 | 0.225 | 19.725 | 20.463 | 235.541 | 235.541 | 319.865 | 529. | -1386. | 0.000 | -0.014 | -0.014 |
| 30 | 26 | -0.400 | 20.000 | 20.462 | 237.389 | 237.389 | 324.298 | 554. | -1237. | 0.000 | -0.015 | -0.015 |
| 31 | 26 | 0.400 | 20.800 | 20.461 | 242.763 | 242.763 | 337.194 | 634. | -762. | 0.000 | -0.015 | -0.015 |
| 32 | 29 | -0.000 | 22.200 | 20.458 | 252.130 | 252.130 | 359.581 | 787. | 230. | -0.000 | -0.016 | -0.016 |
| 33 | 30 | 0.0 | 24.000 | 20.455 | 264.119 | 264.119 | 388.055 | 1012. | 1845. | -0.000 | -0.018 | -0.018 |
| 34 | 32 | -0.200 | 25.600 | 20.452 | 274.726 | 274.726 | 413.090 | 1238. | 3642. | -0.001 | -0.019 | -0.019 |
| 35 | 33 | -0.300 | 26.700 | 20.451 | 281.985 | 293.176 | 430.120 | 1407. | 5195. | -0.001 | -0.020 | -0.020 |
| 36 | 34 | -0.400 | 27.200 | 20.449 | 301.417 | 301.417 | 437.829 | 1481. | 5918. | -0.001 | -0.020 | -0.021 |
| 37 | 34 | 0.400 | 28.000 | 20.447 | 314.577 | 314.577 | 450.088 | 1599. | 7050. | -0.001 | -0.021 | -0.022 |
| 38 | 35 | 0.450 | 28.950 | 20.445 | 330.204 | 330.204 | 464.549 | 1738. | 8634. | -0.001 | -0.021 | -0.023 |
| 39 | 36 | -0.000 | 29.400 | 20.445 | 337.598 | 319.306 | 471.362 | 1803. | 9431. | -0.001 | -0.022 | -0.023 |
| 40 | 35 | 0.450 | 29.850 | 20.444 | 322.683 | 322.683 | 478.152 | 1879. | 10260. | -0.002 | -0.022 | -0.023 |
| 41 | 37 | 0.400 | 30.700 | 20.442 | 336.617 | 336.617 | 490.914 | 2021. | 11917. | -0.002 | -0.023 | -0.024 |
| 42 | 39 | -0.100 | 32.000 | 20.440 | 357.927 | 357.927 | 510.271 | 2236. | 14604. | -0.002 | -0.024 | -0.026 |
| 43 | 40 | 0.0 | 33.000 | 20.438 | 374.319 | 364.133 | 524.986 | 2401. | 17003. | -0.002 | -0.024 | -0.027 |
| 44 | 42 | 0.400 | 35.200 | 20.434 | 413.858 | 413.858 | 556.895 | 2745. | 22692. | -0.003 | -0.026 | -0.029 |

** WAVE COMPONENTS TABLE FOR SHEARING FORCE AND BENDING MOMENT

COND. 1 FULL LOAD CONDITION AT P.C. REP. ROUND BANKER

| | | TROCHOIDAL WAVE | | |
|---|---|---|---|---|
| WAVE | LENGTH | 0.0 M | 320.000M | 320.000M |
| | HEIGHT | 0.0 M | 9.280M | 9.280M |
| | CREST/LBP | 0.0 | 0.100 | 0.500 |
| | CREST(AP) | 0.0 M | 32.000M | 160.000M |

DIFF = (WAVE - STILL)

| BAL. NO | POINT FRNO | POINT DIFF | DISTANCE FROM AP | SF (MT) | BM (MT-M) | DIFF SF (MT) | DIFF BM (MT-M) | DIFF SF (MT) | DIFF BM (MT-M) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -11 | 0.250 | -8.000 | 0. | 0. | 0. | 0. | 0. | 0. |
| 2 | -10 | 0.0 | -7.500 | -27. | -7. | 0. | 0. | -0. | 0. |
| 3 | -9 | 0.001 | -6.749 | -65. | -42. | 2. | 1. | -4. | -1. |
| 4 | -9 | 0.350 | -6.400 | -81. | -67. | 3. | 2. | -8. | -3. |
| 5 | -7 | -0.001 | -5.251 | -125. | -186. | 9. | 8. | -28. | -23. |
| 6 | -5 | -0.250 | -4.000 | -163. | -260. | 19. | 25. | -64. | -79. |
| 7 | -5 | -0.010 | -3.750 | -170. | -410. | 21. | 30. | -73. | -96. |
| 8 | -3 | 0.375 | -1.875 | -206. | -766. | 43. | 89. | -150. | -301. |
| 9 | -2 | -0.100 | -1.600 | -210. | -823. | 47. | 101. | -164. | -345. |
| 10 | 0 | 0.0 | 0.0 | -224. | -1172. | 74. | 197. | -250. | -674. |
| 11 | 2 | -0.252 | 1.250 | -226. | -1494. | 100. | 305. | -328. | -1034. |
| 12 | 2 | 0.0 | 1.500 | -225. | -1517. | 105. | 331. | -344. | -1118. |
| 13 | 3 | 0.0 | 2.250 | -222. | -1678. | 123. | 417. | -395. | -1295. |
| 14 | 4 | 0.200 | 3.200 | -213. | -1885. | 149. | 545. | -463. | -1802. |
| 15 | 5 | 0.250 | 4.000 | -203. | -2057. | 172. | 674. | -525. | -2197. |
| 16 | 6 | 0.0 | 4.500 | -194. | -2151. | 187. | 763. | -565. | -2469. |
| 17 | 6 | 0.333 | 4.833 | -187. | -2210. | 197. | 821. | -589. | -2647. |
| 18 | 9 | -0.350 | 6.400 | -207. | -2535. | 253. | 1180. | -727. | -3694. |
| 19 | 10 | 0.0 | 7.500 | -202. | -2760. | 296. | 1482. | -829. | -4549. |
| 20 | 11 | -0.250 | 8.000 | -196. | -2860. | 317. | 1635. | -877. | -4975. |
| 21 | 14 | 0.0 | 10.500 | -127. | -3273. | 435. | 2571. | -1132. | -7481. |
| 22 | 16 | 0.0 | 12.000 | 4. | -3367. | 515. | 3282. | -1298. | -9203. |
| 23 | 17 | [illegible] | 12.750 | 79. | -3336. | 558. | 3695. | -1304. | -10209. |
| 24 | 17 | 0.350 | 12.850 | 81. | -3232. | 561. | 3713. | -1290. | -10378. |
| 25 | 20 | 0.0 | 15.000 | 204. | -3079. | 699. | 5396. | -1657. | -13726. |
| 26 | 21 | 0.100 | 16.000 | 254. | -2800. | 767. | 5929. | -1783. | -15446. |
| 27 | 23 | -0.100 | 17.400 | 395. | -2317. | 884. | 7149. | -1994. | -18467. |
| 28 | 25 | -0.300 | 19.200 | 482. | -1651. | 1009. | 8662. | -2213. | -21831. |
| 29 | 25 | 0.275 | 19.725 | 529. | -1486. | 1551. | 9202. | -2286. | -23312. |
| 30 | 24 | -0.430 | 20.000 | 554. | -1237. | 1674. | 9494. | -2325. | -23846. |
| 31 | 26 | 0.400 | 20.800 | 634. | -767. | 1147. | 10381. | -2449. | -25552. |
| 32 | 29 | -0.000 | 22.200 | 797. | 230. | 1765. | 12065. | -2644. | -29110. |
| 33 | 30 | 0.0 | 24.000 | 1012. | 1845. | 1432. | 14491. | -2915. | -34113. |
| 34 | 32 | [illegible] | 25.600 | 1238. | 3647. | 1589. | 16907. | -3163. | -38975. |
| 35 | 33 | [illegible] | 26.700 | 1407. | 5495. | 1772. | 18717. | -3336. | -42540. |
| 36 | 34 | -0.400 | 27.200 | 1481. | 5818. | 1754. | 19580. | -3416. | -44237. |
| 37 | 34 | 0.400 | 28.000 | 1599. | 7090. | 1838. | 21017. | -3544. | -47021. |
| 38 | 35 | 0.450 | 28.950 | 1738. | 8634. | 1941. | 22812. | -3699. | -50461. |
| 39 | 36 | -0.000 | 29.400 | 1803. | 9431. | 1991. | 23697. | -3772. | -52142. |
| 40 | 36 | 0.450 | 29.850 | 1879. | 10260. | 2041. | 24605. | -3846. | -53056. |
| 41 | 37 | 0.450 | 30.700 | 2021. | 11917. | 2137. | 26385. | -3986. | -57185. |
| 42 | 39 | -0.100 | 32.000 | 2236. | 14684. | 2287. | 29256. | -4203. | -62508. |
| 43 | 40 | 0.0 | 33.000 | 2401. | 17003. | 2406. | 31602. | -4371. | -66795. |
| 44 | 42 | 0.400 | 35.200 | 2765. | 22697. | 2673. | 37187. | -4744. | -76821. |

** COMPARISION TABLE FOR SHEARING FORCE **

(STILL WATER)

| CAL. POINT NO | CAL. POINT FRND | CAL. POINT DIFF | DISTANCE FROM AP | COND.NO. 2 SF (MT) | COND.NO. 4 SF (MT) | COND.NO. 8 SF (MT) | COND.NO. 10 SF (MT) | COND.NO. 11 SF (MT) |
|---|---|---|---|---|---|---|---|---|
| 64 | 37 | 0.0 | 29.600 | 711. | 711. | 695. | 730. | -1108. |
| 107 | 73 | 0.0 | 58.400 | -4057. | 431. | -115. | -4077. | 939. |
| 125 | 90 | 0.0 | 72.000 | -535. | 246. | -715. | -550. | 1150. |
| 142 | 107 | 0.0 | 85.600 | 2974. | -75. | -1458. | 2980. | 3302. |
| 160 | 124 | 0.0 | 99.200 | 128. | -9. | -49. | 129. | 338. |
| 175 | 141 | 0.0 | 112.800 | -3072. | -131. | 1232. | -3063. | -2944. |
| 195 | 159 | 0.0 | 126.400 | 572. | -161. | 431. | 575. | -1446. |
| 214 | 175 | 0.0 | 140.000 | 4193. | -413. | 197. | 4187. | -97. |
| 257 | 239 | 0.0 | 167.200 | -655. | -654. | -651. | -650. | -18. |

** COMPARISION TABLE FOR BENDING MOMENT **

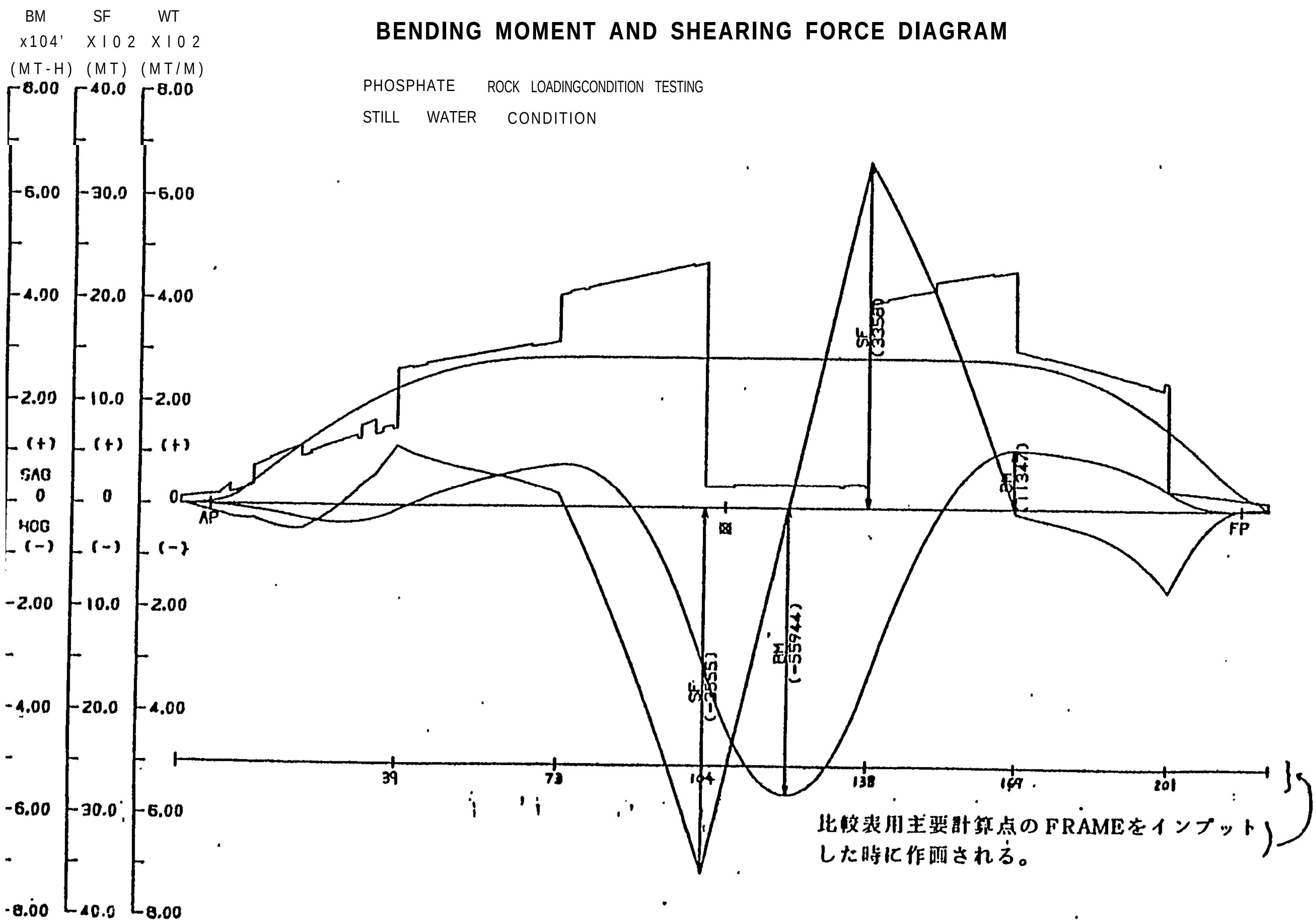
(STILL WATER)

| CAL. POINT NO | CAL. POINT FRND | CAL. POINT DIFF | DISTANCE FROM AP | COND.NO. BM (MT-M) | COND.NO. 4 BM (MT-M) | COND.NO. 8 BM (MT-M) | COND.NO. 10 BM (MT-M) | COND.NO. 11 BM (MT-M) |
|---|---|---|---|---|---|---|---|---|
| 64 | 37 | 0.0 | 29.600 | -3247. | -3247. | -3230. | -2939. | -22927. |
| 107 | 73 | 0.0 | 58.400 | -47610. | 13937. | 6460. | -47141. | -25786. |
| 125 | 90 | 0.0 | 72.000 | -70047. | 16665. | 746. | -70771. | -4648. |
| 142 | 107 | 0.0 | 85.600 | -62100. | 19972. | -13926. | -62265. | 32521. |
| 160 | 124 | 0.0 | 99.200 | -40629. | 12466. | -24083. | -40700. | 57597. |
| 175 | 141 | 0.0 | 112.800 | -60203. | 18895. | -15782. | -60282. | 40302. |
| 195 | 159 | 0.0 | 126.400 | -77219. | 17495. | -1547. | -77230. | 16500. |
| 214 | 175 | 0.0 | 140.000 | -44754. | 13506. | 5735. | -44761. | 479. |
| 257 | 239 | 0.0 | 167.200 | 1975. | 1975. | 1966. | 1959. | -898. |

## BENDING MOMENT AND SHEARING FORCE DIAGRAM

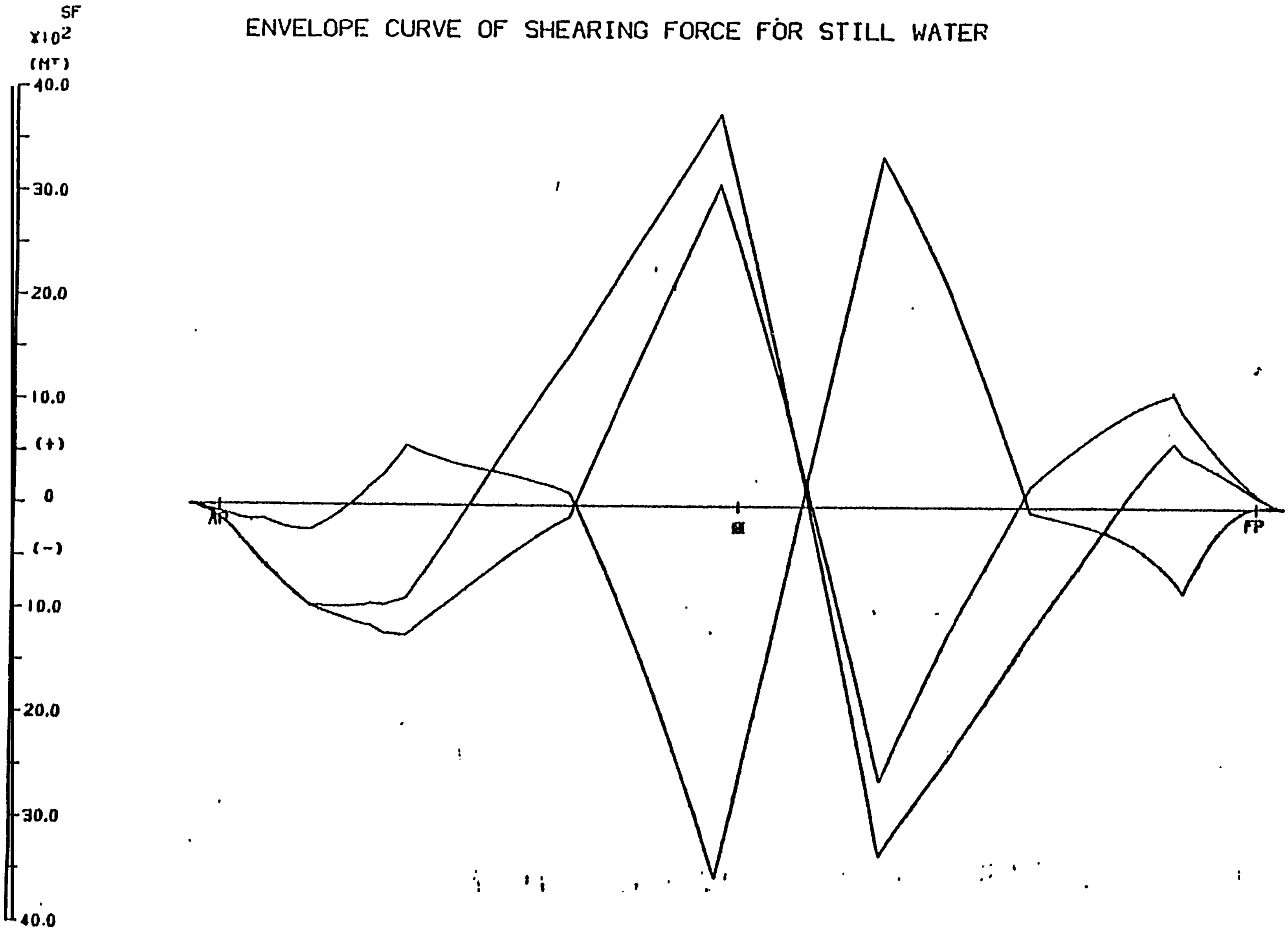
PHOSPHATE ROCK LOADINGCONDITION TESTING

STILL WATER CONDITION

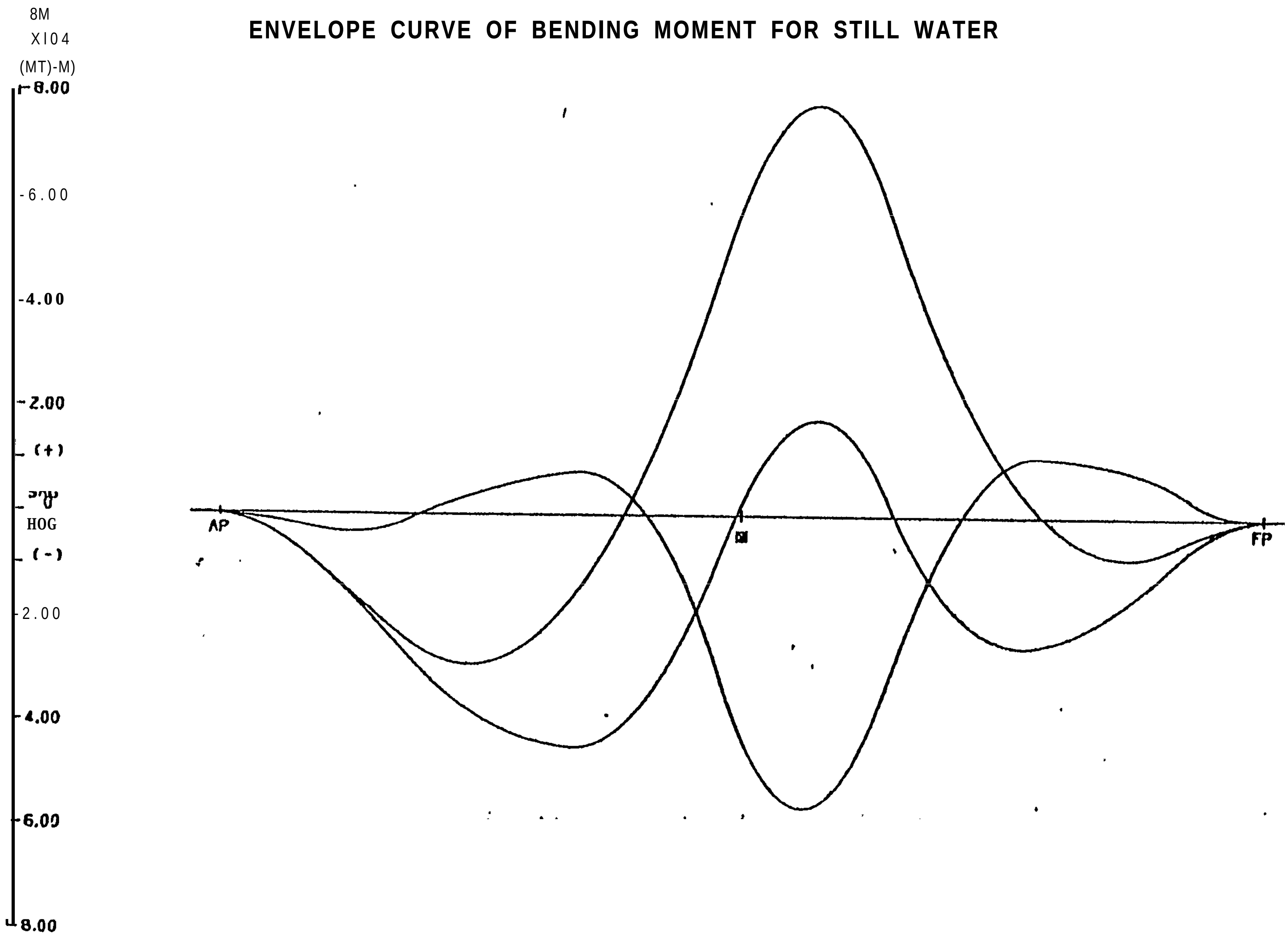



縦強度計算

ENVELOPE CURVE OF SHEARING FORCE FOR STILL WATER



## ENVELOPE CURVE OF BENDING MOMENT FOR STILL WATER




縦強度計算

** PRINT OUT OF APPLICATION DATA **

```
R5J530    DATA FOR SIMPLE CAL. OF LONGITUDINAL STRENGTH

DSLA 1    0   UNIT OF OUT PUT     METRIC SYSTEM
DSLA 2   1.02500
DSLA 3     3.00 27.00  1.00 -3.00  3.00
DSLA 4

DSLB 1     8   4 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32
DSLB 2    33 34  9 10  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
DSLB 3     0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
DSLB 4     0  0  0  0  0  0  0  0  0  0

DSLC 1    28  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
DSLC 2     0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

DSLD 1    61 0.0    14100.  415690. -415690.
DSLD 2    66 0.0    13080.  577540. -577540.
DSLD 3    70 0.0    14490.  739380. -739380.
DSLD 4    74 0.0    13280.  901230. -901230.
DSLD 5    78 0.0    13280.  940900. -940900.
DSLD 6    82 0.0    13280.  980560. -980560.
DSLD 7    86 0.0    13280. 1000390.-1000390.
DSLD 8    90 0.0    13280. 1000390.-1000390.
DSLD 9    94 0.0    13280. 1000390.-1000390.
DSLD10    98 0.0    13280. 1000390.-1000390.
DSLD11   102 0.0    13900.  953160. -953160.
DSLD12   106 0.0    14490.  763680. -763680.
DSLD13   110 0.0    13900.  574200. -574200.
DSLD14   114 0.0    13280.  384720. -384720.
DSLD15   119 0.0    11580.  164580. -164580.
DSLD16     0 0.0        0.       0.       0.
DSLD17     0 0.0        0.       0.       0.
DSLD18     0 0.0        0.       0.       0.
DSLD19     0 0.0        0.       0.       0.
DSLD20     0 0.0        0.       0.       0.
DSLD21     0 0.0        0.       0.       0.
DSLD22     0 0.0        0.       0.       0.
DSLD23     0 0.0        0.       0.       0.
DSLD24     0 0.0        0.       0.       0.
DSLD25     0 0.0        0.       0.       0.
DSLD26     0 0.0        0.       0.       0.
DSLD27     0 0.0        0.       0.       0.
DSLD28     0 0.0        0.       0.       0.
DSLD29     0 0.0        0.       0.       0.
DSLD30     0 0.0        0.       0.       0.
```

## 重量分配係数

** COEFFICIENT OF WEIGHT DISTRIBUTION FOR SHEARING FORCE **

| TANK NAME | FRAME NO. (57.000) | FRAME NO. (59.000) | FRAME NO. (63.000) | FRAME NO. (69.000) | FRAME NO. (75.000) | FRAME NO. (81.000) | FRAME NO. (87.000) | FRAME NO. (93.000) | FRAME NO. (99.000) | FRAME NO. (104.000) |
|---|---|---|---|---|---|---|---|---|---|---|
| DRINK WATER TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1 FRESH WATER T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.2 FRESH WATER T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIST. WATER T. (P/S) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1 FUEL OIL T.(S) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.2 FUEL OIL T.(P) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1&2 F.O.S.T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIESEL OIL TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FORE PEAK TANK | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| NO. 1 C.O.T. (C) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.45 | 0.00 |
| NO. 1 C.O.T. (P/S) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.39 | 0.00 |
| NO. 2 C.O.T. (C) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| NO. 2 C.O.T. (P/S) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| NO. 3 W.B.T. (C) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 3 C.O.T. (P/S) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.51 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 4 C.O.T. (C) | 1.00 | 1.00 | 1.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 4 C.O.T. (P/S) | 1.00 | 1.00 | 1.00 | 0.51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 5 C.O.T. (C) | 1.00 | 0.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 5 C.O.T. (P/S) | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SLOP TANK (P/S) | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AFT PEAK TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## BM 算出用 LEVER

** LEVER FOR BENDING MOMENT IN METER UNIT **

| TANK NAME | FRAME NO. (57.000) | FRAME NO. (59.000) | FRAME NO. (63.000) | FRAME NO. (69.000) | FRAME NO. (75.000) | FRAME NO. (81.000) | FRAME NO. (87.000) | FRAME NO. (93.000) | FRAME NO. (99.000) | FRAME NO. (104.000) |
|---|---|---|---|---|---|---|---|---|---|---|
| DRINK WATER TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1 FRESH WATER T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.2 FRESH WATER T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIST. WATER T. (P/S) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1 FUEL OIL T.(S) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.2 FUEL OIL T.(P) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO.1&2 F.O.S.T. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIESEL OIL TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FORE PEAK TANK | 254.45 | 243.85 | 227.65 | 190.85 | 159.05 | 127.25 | 95.45 | 63.65 | 31.85 | 6.00 |
| NO. 1 C.O.T. (C) | 219.75 | 209.15 | 187.95 | 156.15 | 124.35 | 92.55 | 60.75 | 28.95 | 12.95 | 0.00 |
| NO. 1 C.O.T. (P/S) | 217.55 | 205.90 | 183.70 | 153.90 | 122.10 | 90.30 | 58.50 | 26.70 | 12.44 | 0.00 |
| NO. 2 C.O.T. (C) | 174.90 | 164.30 | 143.10 | 111.30 | 79.50 | 47.70 | 15.90 | 0.00 | 0.00 | 0.00 |
| NO. 2 C.O.T. (P/S) | 174.90 | 164.30 | 143.10 | 111.30 | 79.50 | 47.70 | 15.90 | 0.00 | 0.00 | 0.00 |
| NO. 3 W.B.T. (C) | 126.80 | 116.20 | 95.00 | 63.20 | 31.40 | 15.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 3 C.O.T. (P/S) | 127.20 | 116.60 | 95.40 | 63.60 | 31.80 | 15.90 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 4 C.O.T. (C) | 63.54 | 52.94 | 31.74 | 15.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 4 C.O.T. (P/S) | 63.97 | 53.37 | 32.17 | 15.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 5 C.O.T. (C) | 16.49 | 10.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NO. 5 C.O.T. (P/S) | 21.58 | 10.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SLOP TANK (P/S) | 5.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AFT PEAK TANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

** LONGITUDINAL STRENGTH DATA, NOT INCLUDED IN LIGHT WEIGHT **

3.00 METER BASE DRAFT    S.G.= 1.02500

UNIT: SHEARING FORCE IN METRIC TON/1000
BENDING MOMENT IN METRIC TON-METER/1000

| | SHEARING FORCE | | | BENDING MOMENT | | |
|---|---|---|---|---|---|---|
| LOCATION | BASE VALUE (SF) | DRAFT CORRECT. (CD) | TRIM CORRECT. (CT) | BASE VALUF (BM) | DRAFT CORRECT. (CD) | TRIM CORRECT. (CT) |
| FR.(119.000) | 1.20 | 0.52 | -0.49 | 9.07 | 4.29 | -4.05 |
| FR.(114.000) | 4.51 | 1.76 | -1.61 | 73.59 | 30.24 | -28.18 |
| FR.(110.000) | 8.30 | 3.10 | -2.76 | 203.32 | 79.58 | -72.67 |
| FR.(106.000) | 12.44 | 4.52 | -3.89 | 414.52 | 157.28 | -140.57 |
| FR.(102.000) | 16.66 | 5.94 | -4.95 | 711.28 | 263.99 | -230.86 |
| FR.( 98.000) | 20.88 | 7.37 | -5.93 | 1094.23 | 399.72 | -341.97 |
| FR.( 94.000) | 25.11 | 8.79 | -6.83 | 1563.36 | 564.48 | -472.25 |
| FR.( 90.000) | 29.33 | 10.21 | -7.65 | 2118.69 | 758.27 | -620.06 |
| FR.( 86.000) | 33.56 | 11.63 | -8.39 | 2760.20 | 981.09 | -783.76 |
| FR.( 82.000) | 37.78 | 13.06 | -9.05 | 3487.87 | 1232.93 | -961.71 |
| FR.( 78.000) | 41.89 | 14.47 | -9.62 | 4300.79 | 1513.75 | -1152.24 |
| FR.( 74.000) | 45.66 | 15.82 | -10.09 | 5194.54 | 1822.90 | -1353.47 |
| FR.( 70.000) | 48.91 | 17.03 | -10.44 | 6160.22 | 2158.26 | -1563.13 |
| FR.( 66.000) | 51.49 | 18.02 | -10.68 | 7185.45 | 2516.13 | -1778.78 |
| FR.( 61.000) | 53.32 | 18.76 | -10.81 | 8255.75 | 2891.70 | -1998.15 |

COND 1 FULL LOAD CONDITION AT P.G. DEP. ROUND BANKER

AFT DRAFT 25.04 METER UNIT1. SHEARING FORCE IN METRIC TON
BASE DRAFT 25.00 METER BENDING MOMENT IN METRIC TON-METER
TRIM 0.01 METER
S.G. OF S.M. 1.02500

| LOCATION | SHEARING FORCE | BENDING MOMENT |
|---|---|---|
| FR.(119.000) | -6990. | 53630. |
| FR.(114.000) | -1720. | 153990. |
| FR.(110.000) | 1560. | 154800. |
| FR.(106.000) | 4650. | 91260. |
| FR.(102.000) | -4150. | 86040. |
| FR.(98.000) | -1040. | 139060. |
| FR.(94.000) | 2130. | 127890. |
| FR.(90.000) | 5370. | 51160. |
| FR.(86.000) | 8530. | -90570. |
| FR.(82.000) | -190. | -175610. |
| FR.(78.000) | -8070. | -82960. |
| FR.(74.OOO) | -5540. | 64280. |
| FR.(70.000) | -1860. | 140490. |
| FR.(66.000) | 2430. | 133970. |
| FR.(61.000) | 6290. | 44470. |

** LIGHT WEIGHT DATA **

LIGHT WEIGHT (LW) = 3000. MT.
MIDSHIP G. (XG) = 2.500 M.
(LW) * (XG) = 7500. MT-M.

| CAL.P.NO. | 1ST INTEG. | 2ND INTEG. |
|---|---|---|
| 0 | 120. | 326. |
| 1 | 261. | 1304. |
| 2 | 261. | 1304. |
| 3 | 522. | 5217. |
| 4 | 522. | 5217. |
| 5 | 522. | 5217. |

** BONJEAN DATA FOR SEAMATE-4,8 **

MINIMUM DRAFT 1.00 METER
DRAFT INTERVAL 4.00 METER
NUMBER OF DRAFT 5

| | MEAN DRAFT | | | | |
|---|---|---|---|---|---|
| BONJ. NO. | 1.00 | 5.00 | 9.00 | 13.00 | 17.00 |
| 0 | 40.00 | 200.00 | 360.00 | 520.00 | 680.00 |
| 1 | 40.00 | 200.00 | 360.00 | 520.00 | 680.00 |
| 2 | 40.00 | 200.0? | 360.00 | 520.00 | 680.00 |

** DIFFERENCE TABLE OF BUOYANCY **
(DIFF = SIMPSON - TRAPEZOID)

| | | MEAN DRAFT | | | | |
|---|---|---|---|---|---|---|
| | | 1.00 | 5.00 | 9.00 | 13.00 | 17.00 |
| CAL.P.NO. | PREP.NO.OF BONJEAN | DIFFERENCE IN CUB. M. | | | | |
| 0 | 2 | -0. | -0. | -0. | -0. | -0. |
| 1 | 0 | 0. | 0. | 0. | 0. | 0. |
| 2 | 0 | 0. | 0. | 0. | 0. | 0. |
| 3 | 0 | 0. | 0. | 0. | 0. | 0. |
| 4 | 0 | 0. | 0. | 0. | 0. | 0. |
| 5 | 0 | 0. | 0. | 0. | 0. | 0. |

## ** TANK TABLE FOR SEAMATE-8 **

| TANK NO. (OLD) | TANK NO. (NEW) | TANK NAME | MID.G. (M) | EMPTY (VOL) (M**3) | EMPTY (KG) (M) | MIDDLE (VOL) (M**3) | MIDDLE (KG) (M) | FULL (VOL) (M**3) | FULL (KG) (M) | MAXMUM T.INERTIA (M**4) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1 | FORE PEAK TANK (C) | -52.500 | 0.0 | 0.0 | 2000.0 | 5.000 | 4300.0 | 10.760 | 26667. |
| 11 | 2 | NO.1 W. B. T. (P&S) | -45.000 | 0.0 | 0.0 | 600.0 | 1.000 | 1500.0 | 2.500 | 5625. |
| 12 | 3 | NO.2 W. B. T. (P&S) | -35.000 | 0.0 | 0.0 | 600.0 | 1.000 | 1500.0 | 2.500 | 5625. |
| 13 | 4 | NO.3 W. B. T. (P&S) | -20.000 | 0.0 | 0.0 | 1200.0 | 1.000 | 3000.0 | 2.500 | 11250. |
| 14 | 5 | NO.4 W. B. T. (P&S) | 0.000 | 0.0 | 0.0 | 1200.0 | 1.000 | 3000.0 | 2.500 | 11250. |
| 15 | 6 | AFT PEAK TANK (C) | 55.000 | 0.0 | 0.0 | 4000.0 | 5.000 | 8320.0 | 10.499 | 53333. |
| 1 | 7 | FRESH WATER T. (P&S) | 34.265 | 0.0 | 10.000 | 700.0 | 13.357 | 1700.0 | 16.402 | 1667. |
| 5 | 8 | NO.1 F. O. T. (P&S) | 20.000 | 0.0 | 0.0 | 1200.0 | 1.000 | 3000.0 | 2.500 | 11250. |
| 6 | 9 | DIESEL OIL TANK(P&S) | 35.000 | 0.0 | 0.0 | 200.0 | 1.000 | 500.0 | 2.500 | 208. |
| 21 | 10 | NO.1 CARGO HOLD (C) | -45.000 | 0.0 | 5.000 | 2000.0 | 8.500 | 6720.0 | 13.428 | 53333. |
| 22 | 11 | NO.2 CARGO HOLD (C) | -35.000 | 0.0 | 5.000 | 2800.0 | 8.500 | 6960.0 | 13.792 | 53333. |
| 23 | 12 | NO.3 CARGO HOLD (C) | -20.000 | 0.0 | 5.000 | 5600.0 | 8.500 | 13800.0 | 13.708 | 106667. |
| 24 | 13 | NO.4 CARGO HOLD (C) | 0.0 | 0.0 | 5.000 | 5600.0 | 8.500 | 13666.6 | 13.633 | 106667. |
| 25 | 14 | NO.5 CARGO HOLD (C) | 20.000 | 0.0 | 5.000 | 5600.0 | 8.500 | 13800.0 | 13.708 | 106667. |

## ** TANK TABLE FOR SEAMATE-4,8 **

| TANK NO. (OLD) | TANK NO. (NEW) | TANK NAME | MID.G. (M) | AFT FRNO | AFT DIFF | FORE FRNO | FORE DIFF | FLAT |
|---|---|---|---|---|---|---|---|---|
| 10 | 1 | FORE PEAK TANK (C) | -52.500 | 100 | 0.0 | 105 | 0.0 | 0 |
| 11 | 2 | NO.1 W. B. T. (P&S) | -45.000 | 90 | 0.0 | 100 | 0.0 | 0 |
| 12 | 3 | NO.2 W. B. T. (P&S) | -35.000 | 80 | 0.0 | 95 | 0.0 | 0 |
| 13 | 4 | NO.3 W. B. T. (P&S) | -20.000 | 60 | 0.0 | 80 | 0.0 | 0 |
| 14 | 5 | NO.4 W. B. T. (P&S) | 0.000 | 40 | 0.0 | 60 | 0.0 | 0 |
| 15 | 6 | AFT PEAK TANK (C) | 55.000 | -10 | 0.0 | 0 | 0.0 | 0 |
| 1 | 7 | FRESH WATER T. (P&S) | 34.265 | 10 | 0.0 | 20 | 0.0 | 0 |
| 5 | 8 | NO.1 F. O. T. (P&S) | 20.000 | 20 | 0.0 | 40 | 0.0 | 0 |
| 6 | 9 | DIESEL OIL TANK(P&S) | 35.000 | 10 | 0.0 | 20 | 0.0 | 0 |
| 21 | 10 | NO.1 CARGO HOLD (C) | -45.000 | 90 | 0.0 | 100 | 0.0 | 0 |
| 22 | 11 | NO.2 CARGO HOLD (C) | -35.000 | 80 | 0.0 | 90 | 0.0 | 0 |
| 23 | 12 | NO.3 CARGO HOLD (C) | -20.000 | 60 | 0.0 | 80 | 0.0 | 0 |
| 24 | 13 | NO.4 CARGO HOLD (C) | 0.0 | 40 | 0.0 | 60 | 0.0 | 0 |
| 25 | 14 | NO.5 CARGO HOLD (C) | 20.000 | 20 | 0.0 | 40 | 0.0 | 0 |

SEA MATE用 DATA算出

LAUNCHING PARTICULAR

CASE NO. (1- 1- )

LAUNCHING WEIGHT (WITHOUT SLIDING WAY) = 10411.60 MT

LCG FROM MIDSHIP = 10.920 M

KG = 11.150 M

LAUNCHING WEIGHT (WITH SLIDING WAY) = 10579.96 MT

LCG FROM MIDSHIP = 10.586 M

KG = 10.969 M

LAUNCHING PARTICULAR (その2)

SLIDING WAY :

進水重量 関係データ

DECLIVITY BETWEEN AP AND FP = 7.167 M

DECLIVITY BETWEEN POPPET = 5.821 M

(OUTPUT 数 …. 走行データ数 × 進水重量データ数)
MAX. 2 MAX. 10

COEFFICIENT :

STATICAL FRECTINAL COEFFICIENT BETWEEN WAYS = 0.035000

DYNAMICAL FRECTINAL COEFFICIENT BETWEEN WAYS = 0.022000

COEFFICIENT OF WATER RESISTANCE = 0.070000

THE RATE OF INCREASE OF VERTUAL MASS = 0.200000

AREA OF BEARING SURFACE = 640.0 SQ.M

MEAN PRESSURE BEFORE LAUNCHING = 16.53 MT/SQ.M

INITIAL LAUNCHING FORCE AT F.C. = 18.03 MT

RUNNING DRAG WEIGHT DATA :

| DRAG NO. | DRAG WT. (MT) | TRAVEL(M ) START | FINISH | COEFF. BETWEEN DRAG WT. AND GROUND | INCLINATION ANGLE OF GROUND |
|---|---|---|---|---|---|
| 1 | 200.00 | 10.0 | 999.0 | 0.330000 | 0.036000 |
| 2 | 100.00 | 50.0 | 999.0 | 0.330000 | 0.036000 |

TOTAL
DRAG WT. 300.00

LAUNCHING CALCULATION

CASE NO.(1- 1-1)

| | | WEIGHT(MT) | LCG(M) |
|---|---|---|---|
| LAUNCHING WT. | (WITH SLIDING WAY) | 17745.04 | 11.091 |
| | (WITHOUT SLIDING WAY) | 17480.00 | 11.300 |

→ 作画時 CASE NO. 記入は ○内の CASE NO. を用いる.

HEIGHT OF TIDE 4.35 (M)

| TRAVEL (M) | DRAFT (M) AT AP | DRAFT (M) AT FP | BUOYANCY (MT) | TIPPING MOMENT (MT-M) | LIFTING MOMENT (MT-M) | PRESS. (MT/SQ.M) AFT | PRESS. (MT/SQ.M) FORE |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.988 | -7.966 | 16.4 | 2444059. | 3255. | 34.32 | 14.27 |
| 5.0 | 1.242 | -7.805 | 40.8 | 2374957. | 7888. | 34.20 | 14.33 |
| 10.0 | 1.497 | -7.643 | 60.0 | 2284463. | 11503. | 34.10 | 14.37 |
| 15.0 | 1.759 | -7.479 | 76.8 | 2195127. | 14613. | 34.02 | 14.41 |
| 20.0 | 2.014 | -7.312 | 94.1 | 2105899. | 17712. | 33.94 | 14.44 |
| 25.0 | 2.275 | -7.144 | 116.1 | 2016554. | 21418. | 33.84 | 14.48 |
| 30.0 | 2.538 | -6.974 | 141.5 | 1927163. | 26035. | 33.72 | 14.52 |
| 35.0 | 2.803 | -6.802 | 182.5 | 1837253. | 32981. | 33.55 | 14.58 |
| 40.0 | 3.070 | -6.628 | 235.5 | 1746977. | 41831. | 33.33 | 14.66 |
| 45.0 | 3.339 | -6.452 | 326.7 | 1655715. | 56672. | 32.97 | 14.77 |
| 50.0 | 3.610 | -6.274 | 447.7 | 1563272. | 76182. | 32.49 | 14.92 |
| 55.0 | 3.883 | -6.094 | 627.3 | 1469753. | 104554. | 32.54 | 14.75 |
| 60.0 | 4.158 | -5.913 | 868.1 | 1375532. | 142304. | 34.95 | 12.99 |
| 65.0 | 4.434 | -5.729 | 1169.9 | 1281100. | 188719. | 36.85 | 11.48 |
| 70.0 | 4.713 | -5.543 | 1532.6 | 1187147. | 243908. | 38.64 | 9.93 |
| 75.0 | 4.993 | -5.356 | 1957.2 | 1094241. | 307430. | 40.26 | 8.39 |
| 80.0 | 5.276 | -5.167 | 2443.3 | 1003515. | 379403. | 41.65 | 6.85 |
| 85.0 | 5.560 | -4.975 | 2981.9 | 914283. | 458208. | 42.83 | 5.33 |
| 90.0 | 5.846 | -4.782 | 3591.6 | 828957. | 544323. | 43.77 | 3.91 |
| 95.0 | 6.135 | -4.587 | 4237.1 | 747066. | 635020. | 44.37 | 2.53 |
| 100.0 | 6.425 | -4.390 | 4930.2 | 670295. | 731190. | 44.58 | 1.36 |
| 105.0 | 6.717 | -4.191 | 5663.7 | 598210. | 831518. | 44.37 | 0.33 |
| 110.0 | 7.011 | -3.990 | 6439.9 | 532183. | 936404. | 43.72 | -0.33 |
| 115.0 | 7.306 | -3.787 | 7248.4 | 472326. | 1044317. | 42.37 | -0.64 |
| 120.0 | 7.604 | -3.582 | 8097.1 | 419855. | 1155811. | 40.43 | -0.56 |
| 125.0 | 7.904 | -3.376 | 8977.7 | 374448. | 1271741. | 37.23 | 0.36 |
| 130.0 | 8.205 | -3.167 | 9901.0 | 338078. | 1391850. | 33.02 | 2.00 |
| 135.0 | 8.509 | -2.957 | 10867.4 | 310067. | 1517037. | 26.86 | 5.12 |
| 140.0 | 8.814 | -2.744 | 11875.0 | 293144. | 1647252. | 19.07 | 9.53 |
| 145.0 | 9.122 | -2.530 | 12935.4 | 287034. | 1784430. | 8.36 | 16.55 |
| 150.0 | 9.432 | -2.313 | 14046.0 | 292894. | 1927688. | -6.36 | 26.05 |
| 155.0 | 9.694 | -2.095 | 15009.2 | | | | |
| 160.0 | 9.740 | -1.875 | 15309.0 | | | | |
| 165.0 | 9.573 | -1.653 | 15222.3 | | | | |
| 170.0 | 9.220 | -1.429 | 15033.8 | | | | |
| 175.0 | 9.101 | -1.203 | 15139.8 | | | | |
| 180.0 | 8.979 | -0.975 | 15248.5 | | | | |
| 185.0 | 8.853 | -0.744 | 15359.7 | | | | |
| 190.0 | 8.725 | -0.514 | 15473.7 | | | | |
| 195.0 | 8.595 | -0.280 | 15594.9 | | | | |
| 200.0 | 8.463 | -0.045 | 15721.9 | | | | |
| 205.0 | 8.329 | 0.193 | 15856.6 | | | | |
| 210.0 | 8.193 | 0.432 | 15998.3 | | | | |
| 215.0 | 8.054 | 0.673 | 16147.5 | | | | |
| 220.0 | 7.913 | 0.916 | 16303.8 | | | | |
| 225.0 | 7.769 | 1.162 | 16464.5 | | | | |
| 230.0 | 7.623 | 1.409 | 16630.5 | | | | |
| 235.0 | 7.475 | 1.659 | 16801.8 | | | | |
| 240.0 | 7.326 | 1.909 | 16973.3 | | | | |
| 245.0 | 7.175 | 2.161 | 17150.3 | | | | |

LIFT BY STERN 迄

進水計算結果

*** FOR CHECK ***

| TRAVEL (M) | LCB (M) | T.KM (M) |
|---|---|---|
| 0.0 | 96.04 | 0.38 |
| 5.0 | 92.09 | 0.26 |
| 10.0 | 89.43 | 0.24 |
| 15.0 | 87.56 | 0.29 |
| 20.0 | 85.97 | 0.44 |
| 25.0 | 83.90 | 0.70 |
| 30.0 | 81.62 | 1.08 |
| 35.0 | 78.70 | 2.96 |
| 40.0 | 75.29 | 5.92 |
| 45.0 | 71.56 | 12.59 |
| 50.0 | 67.78 | 19.44 |
| 55.0 | 64.29 | 25.87 |
| 60.0 | 61.54 | 33.71 |
| 65.0 | 59.03 | 36.10 |
| 70.0 | 56.76 | 37.16 |
| 75.0 | 54.81 | 36.90 |
| 80.0 | 52.89 | 35.35 |
| 85.0 | 50.97 | 33.55 |
| 90.0 | 49.17 | 31.67 |
| 95.0 | 47.50 | 30.31 |
| 100.0 | 45.92 | 28.99 |
| 105.0 | 44.43 | 27.67 |
| 110.0 | 43.02 | 26.47 |
| 115.0 | 41.68 | 25.39 |
| 120.0 | 40.42 | 24.44 |
| 125.0 | 39.26 | 23.63 |
| 130.0 | 38.19 | 22.89 |
| 135.0 | 37.20 | 22.20 |
| 140.0 | 36.32 | 21.58 |
| 145.0 | 35.56 | 21.03 |
| 150.0 | 34.87 | 20.53 |
| 155.0 | 34.21 | 20.14 |
| 160.0 | 33.43 | 19.97 |
| 165.0 | 32.54 | 19.94 |
| 170.0 | 31.54 | 19.95 |
| 175.0 | 30.62 | 19.85 |
| 180.0 | 29.67 | 19.75 |
| 185.0 | 28.72 | 19.65 |
| 190.0 | 27.75 | 19.55 |
| 195.0 | 26.74 | 19.44 |
| 200.0 | 25.70 | 19.32 |
| 205.0 | 24.61 | 19.21 |
| 210.0 | 23.48 | 19.08 |
| 215.0 | 22.32 | 18.96 |
| 220.0 | 21.12 | 18.84 |
| 224.0 | 19.92 | 18.71 |
| 230.0 | 18.70 | 18.58 |
| 235.0 | 17.46 | 18.45 |
| 240.0 | 16.21 | 18.33 |
| 245.0 | 14.97 | 18.20 |

LAUNCHING SPEED

| CASE NO.(1- 1-1) | | WEIGHT(MT) | LCG(M) |
|---|---|---|---|
| LAUNCHING WT. | (WITH SLIDING WAY ) | 17744.04 | 11.091 |
| | (WITHOUT SLIDING WAY) | 17400.00 | 11.300 |

HEIGHT OF TIDE 4.35 (M)
TOTAL DRAG WEIGHT 420.00 (MT)

進水 SPEED

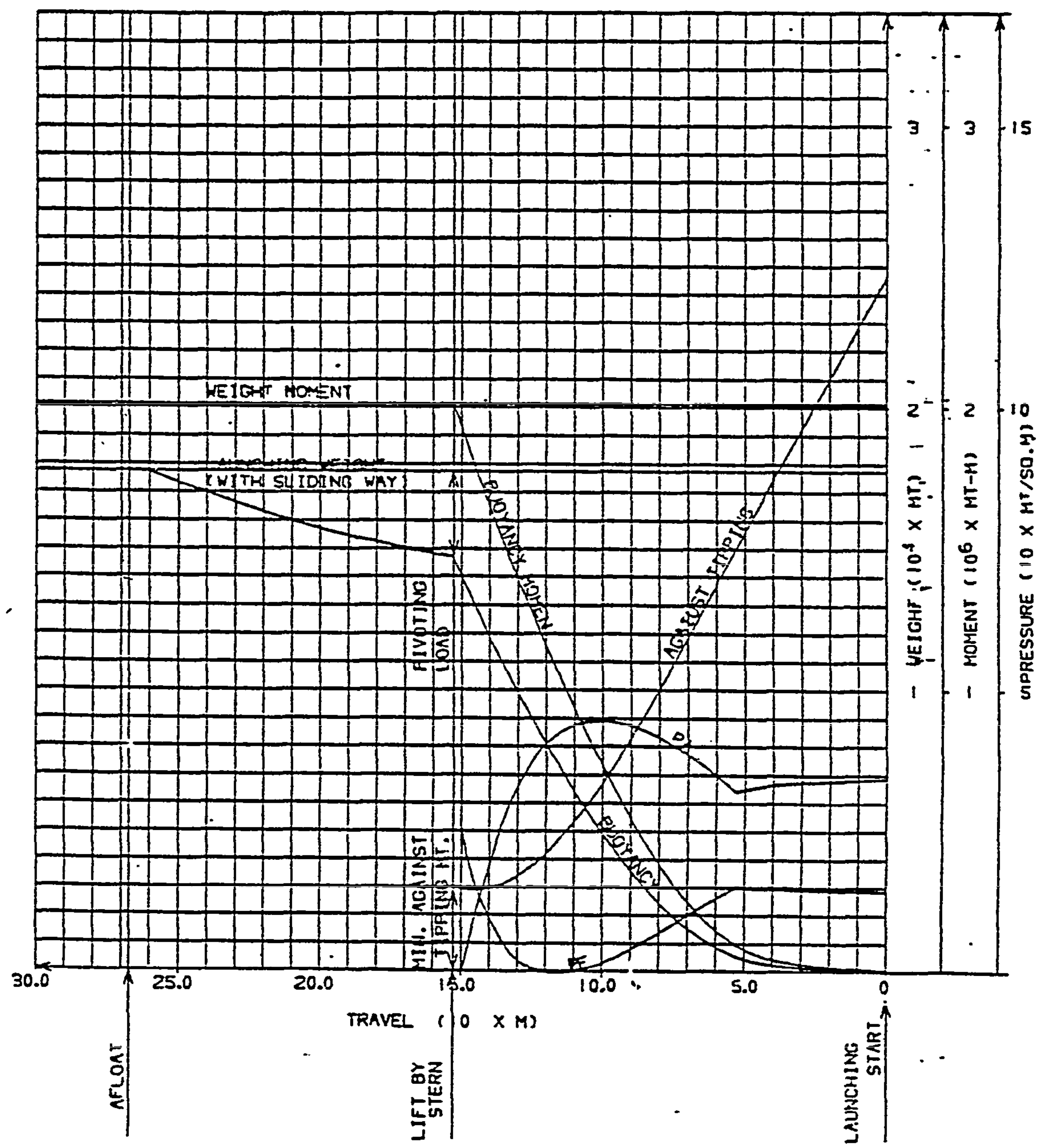
| TRAVEL (M) | SPEED (M/S) | TRAVEL (M) | SPEED (M/S) |
|---|---|---|---|
| 0.0 | 0.00 | 250.0 | 5.38 |
| 5.0 | 1.11 | 255.0 | 5.34 |
| 10.0 | 1.94 | 260.0 | 5.30 |
| 15.0 | 2.37 | 265.0 | 5.26 |
| 20.0 | 2.76 | 270.0 | 5.22 |
| 25.0 | 3.09 | 275.0 | 5.17 |
| 30.0 | 3.39 | 280.0 | 5.10 |
| 35.0 | 3.67 | 285.0 | 5.01 |
| 40.0 | 3.93 | 290.0 | 4.90 |
| 45.0 | 4.15 | 295.0 | 4.80 |
| 50.0 | 4.37 | 300.0 | 4.70 |
| 55.0 | 4.59 | 305.0 | 4.60 |
| 60.0 | 4.78 | 310.0 | 4.50 |
| 65.0 | 4.94 | 315.0 | 4.39 |
| 70.0 | 5.09 | 320.0 | 4.29 |
| 75.0 | 5.22 | 325.0 | 4.19 |
| 80.0 | 5.33 | 330.0 | 4.08 |
| 85.0 | 5.43 | 335.0 | 3.97 |
| 90.0 | 5.52 | 340.0 | 3.86 |
| 95.0 | 5.59 | 345.0 | 3.75 |
| 100.0 | 5.65 | 350.0 | 3.64 |
| 105.0 | 5.70 | 355.0 | 3.53 |
| 110.0 | 5.75 | 360.0 | 3.41 |
| 115.0 | 5.79 | 365.0 | 3.29 |
| 120.0 | 5.81 | 370.0 | 3.17 |
| 125.0 | 5.82 | 375.0 | 3.05 |
| 130.0 | 5.83 | 380.0 | 2.92 |
| 135.0 | 5.83 | 385.0 | 2.79 |
| 140.0 | 5.81 | 390.0 | 2.66 |
| 145.0 | 5.80 | 395.0 | 2.52 |
| 150.0 | 5.77 | 400.0 | 2.37 |
| 155.0 | 5.74 | 405.0 | 2.22 |
| 160.0 | 5.72 | 410.0 | 2.05 |
| 165.0 | 5.70 | 415.0 | 1.98 |
| 170.0 | 5.69 | 420.0 | 1.69 |
| 175.0 | 5.67 | 425.0 | 1.48 |
| 180.0 | 5.66 | 430.0 | 1.24 |
| 185.0 | 5.65 | 435.0 | 0.93 |
| 190.0 | 5.64 | 440.0 | 0.46 |
| 195.0 | 5.63 | 443.1 | 0.0 |
| 200.0 | 5.62 | | |
| 205.0 | 5.61 | | |
| 210.0 | 5.59 | | |
| 215.0 | 5.57 | | |
| 220.0 | 5.55 | | |
| 225.0 | 5.53 | | |
| 230.0 | 5.51 | | |
| 235.0 | 5.49 | | |
| 240.0 | 5.45 | | |
| 245.0 | 5.42 | | |

# 進 水 計 算

## LAUNCHING CURVES

SNO2323

| | | W.I. | I.C.G. |
|---|---|---|---|
| CASE NO. | ( 1- 1- 1) | | |
| LAUNCHING WT. (WITH SLIDING WAY ) | | 17745.03 MT | 11.09M |
| (WITHOUT SLIDING WAY) | | 174H0.00 MT | 11.30M |
| HIGHT OF TIDE | 4.35 M | | |




X REMARK
MOMENT --- . AROUND FORE END OF SLIDING WAY

# 進 水 計 算

## LAUNCHING SPEED AND TRAVEL CURVES

SNO2323

CASE NO. ( 1- 1- 1)
LAUNCHING WT. (WITH SLIDING WAY) 17745.03 MT
(WITHOUT SLIDING WAY) 17480.00 MT
HIGHT OF TIDE 4.35 M
TOTAL DRAG WEIGHT 420.00 MT

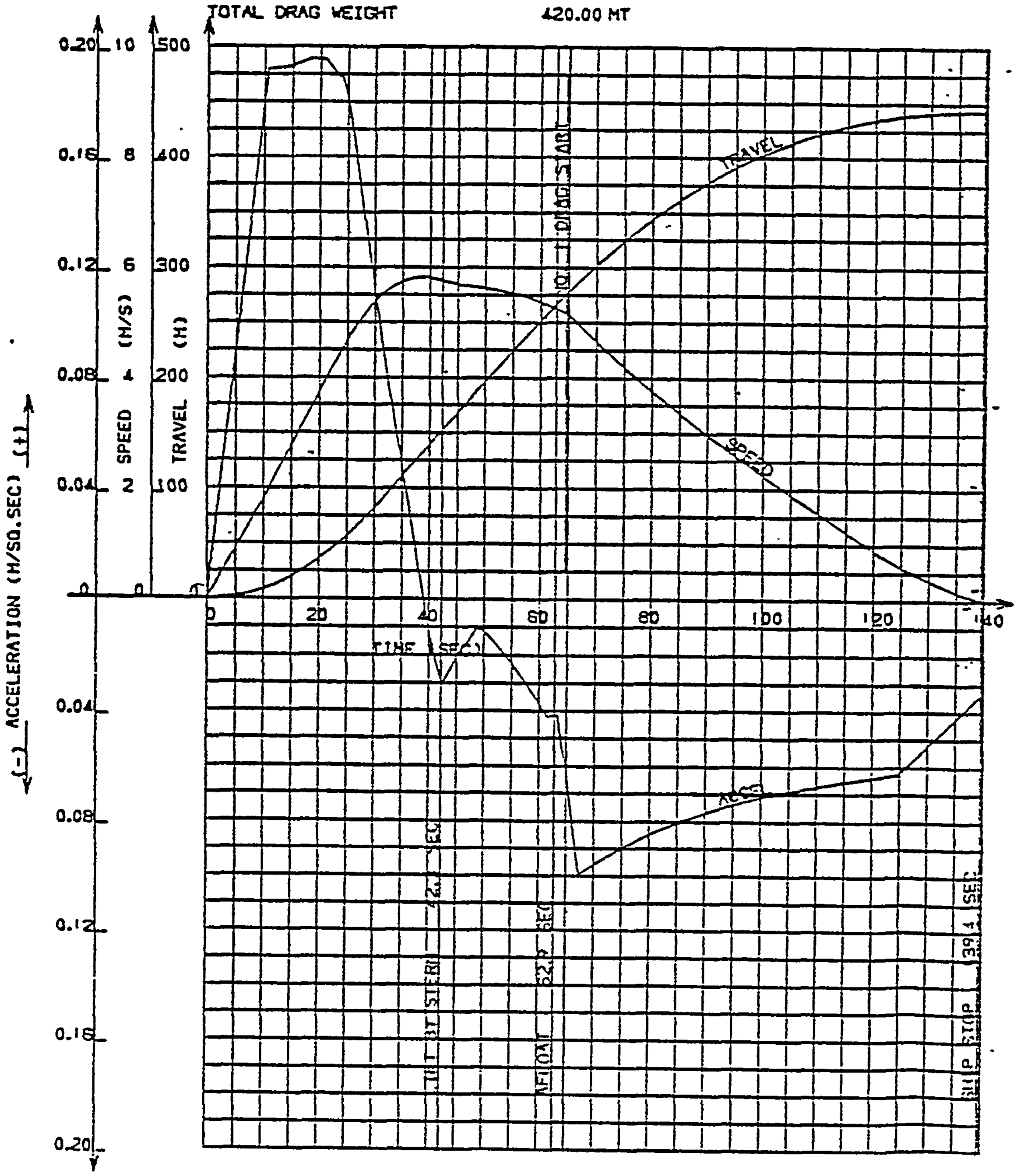


TABLE OF OBSCURED DISTANCE IN RELATION TO VARIOUS DRAFT AND TRIM

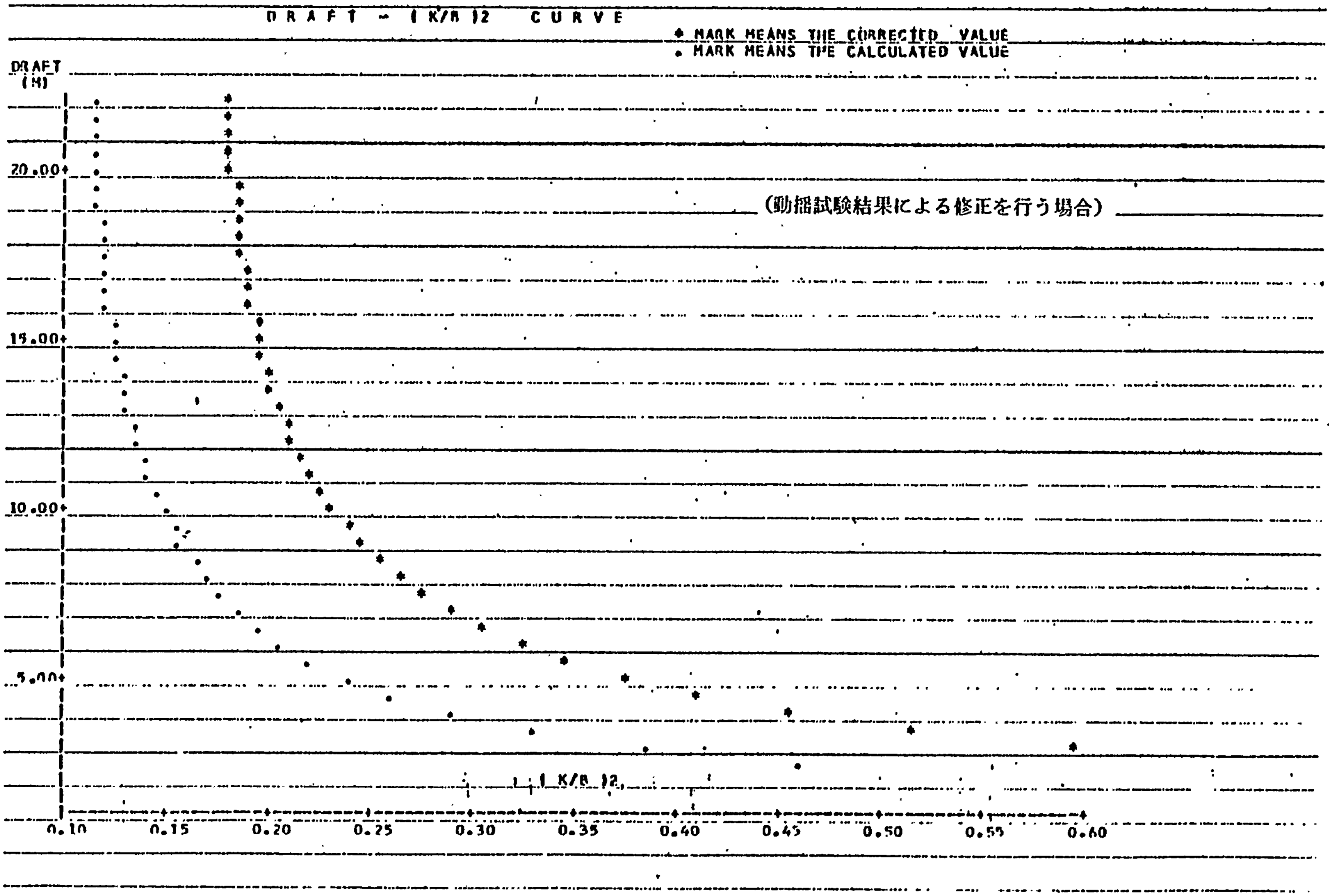
NAME OF OBJECT : BOW CHOCK TOP

OBJECT 329.000 M FROM A.P. EYE POSITION 47.400 M FROM A.P.
32.850 M ABOVE B.L. 47.300 M ABOVE B.L.
0.0 M FROM C.L. 0.0 M FROM C.L.

| MEAN DRAFT (M) | TRIM BY STERN ( - MEANS : BY BOW ) -2.0 | -1.0 | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 |
|---|---|---|---|---|---|---|---|---|---|
| | DISTANCE FROM FORE END ( UNIT = METRIC ) | | | | | | | | |
| 4.00 | 482 | 520 | 562 | 609 | 663 | 725 | 797 | 882 | 983 |
| 6.00 | 448 | 483 | 523 | 568 | 619 | 677 | 746 | 826 | 921 |
| 8.00 | 413 | 446 | 484 | 526 | 574 | 630 | 694 | 770 | 860 |
| 10.00 | 378 | 410 | 445 | 485 | 530 | 582 | 643 | 714 | 799 |
| 12.00 | 343 | 373 | 406 | 443 | 486 | 534 | 591 | 658 | 737 |
| 14.00 | 309 | 336 | 367 | 402 | 441 | 487 | 540 | 602 | 676 |
| 16.00 | 274 | 299 | 328 | 360 | 397 | 439 | 488 | 546 | 614 |
| 18.00 | 239 | 263 | 289 | 319 | 352 | 391 | 437 | 490 | 553 |
| 20.00 | 204 | 226 | 250 | 277 | 308 | 344 | 385 | 434 | 491 |
| 22.00 | 170 | 189 | 211 | 236 | 264 | 296 | 333 | 378 | 430 |

ROLLING PERIOD - GM TABLE

| DRAFT(EXT) (M) | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROLLING PERIOD (SEC) | | | | | | | | | | | | | | |
| | CORRECTED GM = GOM (M) | | | | | | | | | | | | | | |
| 2.50 | 26.43 | 19.42 | 14.87 | 11.75 | 9.52 | 7.86 | 6.61 | 5.63 | 4.85 | 4.21 | 2.38 | 1.52 | 1.06 | 0.78 | 0.59 |
| 2.70 | 24.71 | 18.16 | 13.90 | 10.98 | 8.90 | 7.35 | 6.18 | 5.26 | 4.54 | 3.95 | 2.22 | 1.42 | 0.99 | 0.73 | 0.56 |
| 2.90 | 23.25 | 17.09 | 13.08 | 10.34 | 8.37 | 6.92 | 5.81 | 4.95 | 4.27 | 3.72 | 2.09 | 1.34 | 0.93 | 0.68 | 0.52 |
| 3.10 | 22.01 | 16.17 | 12.38 | 9.78 | 7.92 | 6.55 | 5.50 | 4.69 | 4.04 | 3.52 | 1.98 | 1.27 | 0.88 | 0.65 | 0.50 |
| 3.30 | 20.93 | 15.38 | 11.77 | 9.30 | 7.54 | 6.23 | 5.23 | 4.46 | 3.84 | 3.35 | 1.88 | 1.21 | 0.84 | 0.62 | 0.47 |
| 3.50 | 20.00 | 14.69 | 11.25 | 8.89 | 7.20 | 5.95 | 5.00 | 4.26 | 3.67 | 3.20 | 1.80 | 1.15 | 0.80 | 0.59 | 0.45 |
| 3.70 | 19.18 | 14.09 | 10.79 | 8.52 | 6.90 | 5.71 | 4.79 | 4.08 | 3.52 | 3.07 | 1.73 | 1.10 | 0.77 | 0.56 | 0.43 |
| 3.90 | 18.45 | 13.56 | 10.38 | 8.20 | 6.64 | 5.49 | 4.61 | 3.93 | 3.39 | 2.95 | 1.66 | 1.06 | 0.74 | 0.54 | 0.42 |
| 4.10 | 17.81 | 13.08 | 10.02 | 7.92 | 6.41 | 5.30 | 4.45 | 3.79 | 3.27 | 2.85 | 1.60 | 1.03 | 0.71 | 0.52 | 0.40 |
| 4.30 | 17.24 | 12.66 | 9.70 | 7.66 | 6.20 | 5.13 | 4.31 | 3.67 | 3.17 | 2.76 | 1.55 | 0.99 | 0.69 | 0.51 | 0.39 |
| 4.50 | 16.72 | 12.28 | 9.41 | 7.43 | 6.02 | 4.97 | 4.18 | 3.56 | 3.07 | 2.68 | 1.50 | 0.96 | 0.67 | 0.49 | 0.38 |
| 4.70 | 16.26 | 11.94 | 9.14 | 7.23 | 5.85 | 4.84 | 4.06 | 3.46 | 2.99 | 2.60 | 1.46 | 0.94 | 0.65 | 0.48 | 0.37 |
| 4.90 | 15.84 | 11.64 | 8.91 | 7.04 | 5.70 | 4.71 | 3.96 | 3.37 | 2.91 | 2.53 | 1.43 | 0.91 | 0.63 | 0.47 | 0.36 |
| 5.10 | 15.46 | 11.36 | 8.69 | 6.87 | 5.56 | 4.60 | 3.86 | 3.29 | 2.84 | 2.47 | 1.39 | 0.89 | 0.62 | 0.45 | 0.35 |
| 5.30 | 15.11 | 11.10 | 8.50 | 6.72 | 5.44 | 4.50 | 3.78 | 3.22 | 2.78 | 2.42 | 1.36 | 0.87 | 0.60 | 0.44 | 0.34 |
| 5.50 | 14.79 | 10.87 | 8.32 | 6.57 | 5.33 | 4.40 | 3.70 | 3.15 | 2.72 | 2.37 | 1.33 | 0.85 | 0.59 | 0.43 | 0.33 |
| 5.70 | 14.50 | 10.65 | 8.16 | 6.45 | 5.22 | 4.31 | 3.63 | 3.09 | 2.66 | 2.32 | 1.31 | 0.84 | 0.58 | 0.43 | 0.33 |
| 5.90 | 14.23 | 10.46 | 8.01 | 6.33 | 5.12 | 4.24 | 3.56 | 3.03 | 2.61 | 2.28 | 1.28 | 0.82 | 0.57 | 0.42 | 0.32 |
| 6.10 | 13.99 | 10.28 | 7.87 | 6.22 | 5.04 | 4.16 | 3.50 | 2.98 | 2.57 | 2.24 | 1.26 | 0.81 | 0.56 | 0.41 | 0.31 |
| 6.30 | 13.76 | 10.11 | 7.74 | 6.12 | 4.95 | 4.09 | 3.44 | 2.93 | 2.53 | 2.20 | 1.24 | 0.79 | 0.55 | 0.40 | 0.31 |
| 6.50 | 13.55 | 9.96 | 7.62 | 6.02 | 4.88 | 4.03 | 3.39 | 2.89 | 2.49 | 2.17 | 1.22 | 0.78 | 0.54 | 0.40 | 0.30 |
| 6.70 | 13.36 | 9.81 | 7.51 | 5.94 | 4.81 | 3.97 | 3.34 | 2.84 | 2.45 | 2.14 | 1.20 | 0.77 | 0.53 | 0.39 | 0.30 |
| 6.90 | 13.17 | 9.68 | 7.41 | 5.86 | 4.74 | 3.92 | 3.29 | 2.81 | 2.42 | 2.11 | 1.19 | 0.76 | 0.53 | 0.39 | 0.30 |
| 7.10 | 13.01 | 9.56 | 7.32 | 5.78 | 4.68 | 3.87 | 3.25 | 2.77 | 2.39 | 2.08 | 1.17 | 0.75 | 0.52 | 0.38 | 0.29 |
| 7.30 | 12.85 | 9.44 | 7.23 | 5.71 | 4.63 | 3.82 | 3.21 | 2.74 | 2.36 | 2.06 | 1.16 | 0.74 | 0.51 | 0.38 | 0.29 |
| 7.50 | 12.70 | 9.33 | 7.15 | 5.65 | 4.57 | 3.78 | 3.18 | 2.71 | 2.33 | 2.03 | 1.14 | 0.73 | 0.51 | 0.37 | 0.29 |
| 7.70 | 12.57 | 9.23 | 7.07 | 5.59 | 4.52 | 3.74 | 3.14 | 2.68 | 2.31 | 2.01 | 1.13 | 0.72 | 0.50 | 0.37 | 0.28 |
| 7.90 | 12.44 | 9.14 | 7.00 | 5.53 | 4.48 | 3.70 | 3.11 | 2.65 | 2.28 | 1.99 | 1.12 | 0.72 | 0.50 | 0.37 | 0.28 |
| 8.10 | 12.32 | 9.05 | 6.93 | 5.48 | 4.44 | 3.67 | 3.08 | 2.62 | 2.26 | 1.97 | 1.11 | 0.71 | 0.49 | 0.36 | 0.28 |
| 8.30 | 12.21 | 8.97 | 6.87 | 5.43 | 4.40 | 3.63 | 3.05 | 2.60 | 2.24 | 1.95 | 1.10 | 0.70 | 0.49 | 0.36 | 0.27 |
| 8.50 | 12.11 | 8.89 | 6.01 | 5.38 | 4.36 | 3.60 | 3.03 | 2.58 | 2.22 | 1.94 | 1.09 | 0.70 | 0.48 | 0.36 | 0.27 |
| 8.70 | 12.01 | 8.82 | 6.76 | 5.34 | 4.32 | 3.57 | 3.00 | 2.56 | 2.21 | 1.92 | 1.08 | 0.69 | 0.48 | 0.35 | 0.27 |
| 8.90 | 11.92 | 8.76 | 6.70 | 5.30 | 4.29 | 3.55 | 2.98 | 2.54 | 2.19 | 1.91 | 1.07 | 0.69 | 0.48 | 0.35 | 0.27 |
| 9.10 | 11.83 | 8.69 | 6.66 | 5.26 | 4.26 | 3.52 | 2.96 | 2.52 | 2.17 | 1.89 | 1.07 | 0.68 | 0.47 | 0.35 | 0.27 |
| 9.30 | 11.76 | 8.64 | 6.61 | 5.22 | 4.23 | 3.50 | 2.94 | 2.50 | 2.16 | 1.88 | 1.06 | 0.68 | 0.47 | 0.35 | 0.26 |
| 9.50 | 11.68 | 8.58 | 6.57 | 5.19 | 4.21 | 3.48 | 2.92 | 2.49 | 2.15 | 1.87 | 1.05 | 0.67 | 0.47 | 0.34 | 0.26 |
| 9.70 | 11.61 | 8.53 | 6.53 | 5.16 | 4.18 | 3.46 | 2.90 | 2.47 | 2.13 | 1.86 | 1.05 | 0.67 | 0.46 | 0.34 | 0.26 |
| 9.90 | 11.55 | 8.48 | 6.50 | 5.13 | 4.16 | 3.44 | 2.89 | 2.46 | 2.12 | 1.85 | 1.04 | 0.67 | 0.46 | 0.34 | 0.26 |
| 10.10 | 11.49 | 8.44 | 6.46 | 5.11 | 4.14 | 3.42 | 2.87 | 2.45 | 2.11 | 1.84 | 1.03 | 0.66 | 0.46 | 0.34 | 0.26 |
| 10.30 | 11.43 | 8.40 | 6.43 | 5.08 | 4.12 | 3.40 | 2.86 | 2.44 | 2.10 | 1.83 | 1.03 | 0.66 | 0.46 | 0.34 | 0.26 |
| 10.50 | 11.38 | 8.36 | 6.40 | 5.06 | 4.10 | 3.39 | 2.85 | 2.42 | 2.09 | 1.82 | 1.02 | 0.66 | 0.46 | 0.33 | 0.26 |
| 10.70 | 11.34 | 8.33 | 6.38 | 5.04 | 4.08 | 3.37 | 2.83 | 2.41 | 2.08 | 1.81 | 1.02 | 0.65 | 0.45 | 0.33 | 0.26 |
| 10.90 | 11.29 | 8.30 | 6.35 | 5.02 | 4.06 | 3.36 | 2.82 | 2.41 | 2.07 | 1.81 | 1.02 | 0.65 | 0.45 | 0.33 | 0.25 |
| 11.10 | 11.25 | 8.27 | 6.33 | 5.00 | 4.05 | 3.35 | 2.81 | 2.40 | 2.07 | 1.80 | 1.01 | 0.65 | 0.45 | 0.33 | 0.25 |
| 11.30 | 11.21 | 8.24 | 6.31 | 4.98 | 4.04 | 3.34 | 2.80 | 2.39 | 2.06 | 1.79 | 1.01 | 0.65 | 0.45 | 0.33 | 0.25 |
| 11.50 | 11.18 | 8.21 | 6.29 | 4.97 | 4.02 | 3.33 | 2.79 | 2.38 | 2.05 | 1.79 | 1.01 | 0.64 | 0.45 | 0.33 | 0.25 |


DRAFT ~ (K/B)2 CURVE
◆ MARK MEANS THE CORRECTED VALUE
• MARK MEANS THE CALCULATED VALUE
DRAFT (M)
(動揺試験結果による修正を行う場合)
20.00
15.00
10.00
5.00
(K/B)2
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60

可浸長計算

## FLOODABLE LENGTH CALCULATION

VOLUME OF DISPLACEMENT AT FULL LOAD DRAFT (DESIGN DRAFT) 13.325 (M) , 69148.75 (M3)

| DRAFT F. (M) | DRAFT A. (M) | SHIP VOLUME (M3) | SHIP MID. B. (M) | FLOODING VOLUME (M3) | FLOODING MID. B. (M) | CENTER POINT (M) | FLOODABLE LENGTH (M) | PERMISSIBLE LENGTH |
|---|---|---|---|---|---|---|---|---|
| 18.626 | 10.600 | 76655.19 | 111.387 | 6005.00 | 182.372 | 184.232 | 19.878 | 19.878 |
| 18.647 | 11.455 | 79038.81 | 110.277 | 7911.90 | 156.398 | 156.428 | 14.560 | 14.560 |
| 18.667 | 12.309 | 81463.44 | 109.182 | 9851.60 | 140.067 | 139.956 | 17.995 | 17.995 |
| 18.688 | 13.164 | 83926.81 | 108.101 | 11822.30 | 128.781 | 128.530 | 21.429 | 21.429 |
| 18.709 | 14.019 | 86425.00 | 107.036 | 13820.85 | 120.466 | 120.004 | 24.538 | 24.538 |
| 18.729 | 14.874 | 88934.69 | 105.979 | 15828.60 | 114.009 | 113.935 | 28.650 | 28.650 |
| 18.731 | 15.728 | 91429.12 | 104.929 | 17824.15 | 108.800 | 108.986 | 32.283 | 32.283 |
| 18.627 | 16.583 | 93660.62 | 103.840 | 19609.35 | 104.289 | 104.116 | 34.204 | 34.204 |
| 18.484 | 17.438 | 95782.06 | 102.749 | 21306.50 | 100.328 | 100.467 | 37.189 | 37.189 |
| 18.292 | 18.292 | 97474.50 | 101.776 | 22660.45 | 97.125 | 97.075 | 38.866 | 38.866 |
| 18.292 | 18.292 | 97474.50 | 101.776 | 22660.45 | 97.125 | 97.075 | 38.866 | 38.866 |
| 17.438 | 18.460 | 95887.31 | 101.041 | 21390.70 | 94.212 | 94.206 | 37.076 | 37.076 |
| 16.583 | 18.564 | 93799.25 | 100.248 | 19720.25 | 90.615 | 91.004 | 34.004 | 34.004 |
| 15.728 | 18.624 | 91569.31 | 99.404 | 17936.30 | 86.537 | 86.419 | 32.439 | 32.439 |
| 14.874 | 18.649 | 89232.37 | 98.735 | 16066.75 | 81.702 | 81.746 | 29.237 | 29.237 |
| 14.019 | 18.646 | 86816.00 | 97.987 | 14133.65 | 75.702 | 76.208 | 25.158 | 25.158 |
| 13.164 | 18.630 | 84362.06 | 97.224 | 12170.50 | 67.876 | 67.800 | 23.000 | 23.000 |
| 12.309 | 18.612 | 81905.00 | 96.424 | 10204.85 | 57.084 | 57.313 | 19.128 | 19.128 |
| 11.455 | 18.595 | 79444.12 | 95.576 | 8236.15 | 41.135 | 40.884 | 17.723 | 17.723 |
| 10.600 | 18.578 | 76987.25 | 94.671 | 6270.65 | 15.180 | 4.812 | 44.565 | 44.565 |

*** DATA OF FLOODABLE LENGTH CURVES ***

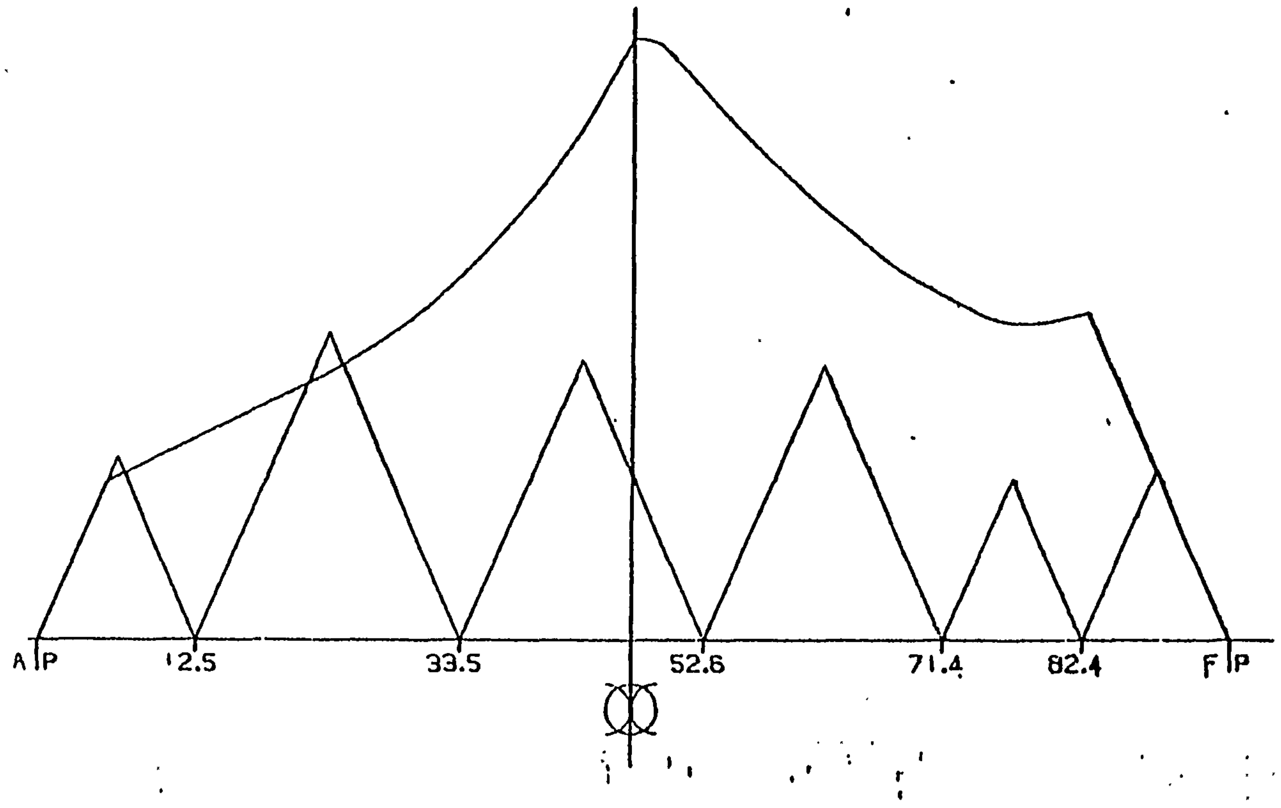
| ... FLOODABLE LENGTH ... | | | ... PERMISSIBLE LENGTH ... | | | |
|---|---|---|---|---|---|---|
| DIS. AP (M) | LENGTH (M) | K.P. | DIS. AP (M) | LENGTH (M) | K.P. | |
| 197.000 | 0.0 | 1 | 197.000 | 0.0 | 1 | ← F.P |
| 173.250 | 14.375 | 1 | 173.250 | 14.375 | 1 | ← TAN LINEとFLOODABLE LENGTHとの交点 |
| 173.183 | 14.366 | 0 | 173.183 | 14.366 | 0 | |
| 172.886 | 14.329 | 0 | 172.886 | 14.329 | 0 | |
| 172.402 | 14.277 | 0 | 172.402 | 14.277 | 0 | |
| 171.454 | 14.190 | 0 | 171.454 | 14.190 | 0 | |
| 170.884 | 14.140 | 0 | 170.884 | 14.140 | 0 | |
| 169.967 | 14.066 | 0 | 169.967 | 14.066 | 0 | |
| 169.039 | 14.000 | 0 | 169.039 | 14.000 | 0 | |
| 168.460 | 13.966 | 0 | 168.460 | 13.966 | 0 | |
| 167.536 | 13.918 | 0 | 167.536 | 13.918 | 0 | |
| 166.968 | 13.894 | 0 | 166.968 | 13.894 | 0 | |
| 166.397 | 13.875 | 0 | 166.397 | 13.875 | 0 | |
| 166.055 | 13.867 | 0 | 166.055 | 13.867 | 0 | |
| 165.090 | 13.852 | 0 | 165.090 | 13.852 | 0 | |
| 164.513 | 13.849 | 0 | 164.513 | 13.849 | 0 | |
| 163.926 | 13.851 | 0 | 163.926 | 13.851 | 0 | |
| 163.592 | 13.855 | 0 | 163.592 | 13.855 | 0 | |
| 163.016 | 13.868 | 0 | 163.016 | 13.868 | 0 | |
| 162.674 | 13.878 | 0 | 162.674 | 13.878 | 0 | |
| 162.132 | 13.902 | 0 | 162.132 | 13.902 | 0 | |
| 161.110 | 13.957 | 0 | 161.188 | 13.957 | 0 | |
| 160.617 | 13.996 | 0 | 160.617 | 13.996 | 0 | |
| 160.060 | 14.039 | 0 | 160.060 | 14.039 | 0 | |
| 159.732 | 14.068 | 0 | 159.732 | 14.068 | 0 | |
| 159.188 | 14.121 | 0 | 159.188 | 14.121 | 0 | |
| 158.869 | 14.156 | 0 | 158.869 | 14.156 | 0 | |
| 158.371 | 14.218 | 0 | 158.371 | 14.218 | 0 | |
| 157.862 | 14.291 | 0 | 157.862 | 14.291 | 0 | |
| 157.566 | 14.337 | 0 | 157.566 | 14.337 | 0 | |
| 157.107 | 14.416 | 0 | 157.107 | 14.416 | 0 | |
| 156.672 | 14.503 | 0 | 156.672 | 14.503 | 0 | |
| 156.428 | 14.560 | 0 | 156.428 | 14.560 | 0 | |
| 137.956 | 17.995 | 0 | 137.956 | 17.995 | 0 | |
| 128.520 | 21.429 | 0 | 128.520 | 21.429 | 0 | |
| 127.893 | 21.598 | 0 | 127.893 | 21.598 | 0 | |
| 127.518 | 21.703 | 0 | 127.518 | 21.703 | 0 | |
| 126.954 | 21.867 | 0 | 126.954 | 21.867 | 0 | |
| 126.594 | 21.975 | 0 | 126.594 | 21.975 | 0 | |
| 126.056 | 22.143 | 0 | 126.056 | 22.143 | 0 | |
| 125.530 | 22.314 | 0 | 125.530 | 22.314 | 0 | |
| 124.738 | 22.581 | 0 | 124.738 | 22.581 | 0 | |
| 124.410 | 22.695 | 0 | 124.410 | 22.695 | 0 | |
| 123.922 | 22.873 | 0 | 123.922 | 22.873 | 0 | |
| 123.446 | 23.053 | 0 | 123.446 | 23.053 | 0 | |
| 122.735 | 23.332 | 0 | 122.735 | 23.332 | 0 | |
| 122.285 | 23.517 | 0 | 122.285 | 23.517 | 0 | |
| 121.616 | 23.802 | 0 | 121.616 | 23.802 | 0 | |
| 120.969 | 24.090 | 0 | 120.969 | 24.090 | 0 | |
| 120.004 | 24.538 | 0 | 120.004 | 24.538 | 0 | |
| 119.346 | 24.907 | 0 | 119.346 | 24.907 | 0 | |
| 118.804 | 25.246 | 0 | 118.804 | 25.246 | 0 | |

# FLODABLE LENGTH CURVE

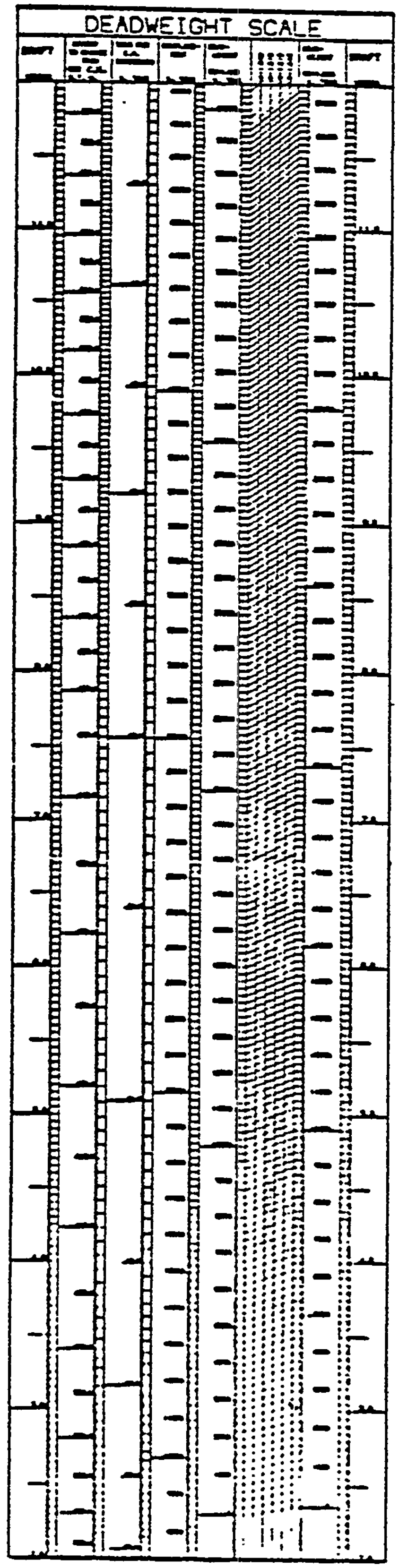
———— FLOODABLE LENGTH
- - - - - - - PERMEABILITY LENGTH
(SCALE ICM = 4.33M)

SUBDIVISION LENGTH 94.0 M
BREADTH 14.0 M
DEPTH 7.6 M

CRITERION NUMBER 16
FACTOR OF SUBDIVISION 1.0
NUMBER OF CREW 325



# D／W スケール作画



### *** INPUT DATA FOR TURNING TEST ***

| | |
|---|---|
| DATE | FEBRUARY 4 1977 |
| PLACE | KURE-1 SHIPYARD |
| COND. | FULL |
| WEATHER | BC |
| SEA COND. | 5 |
| SEA DEPTH | 1500.00 |
| R. WIND DIRECTION | 25.00 |
| R. WIND VELOCITY | 11.00 |
| ENGINE POWER | M.C.R. |
| INITIAL SPEED | 16.20 |
| INITIAL COURSE | 270.00 |
| INITIAL RPM | 83.00 |
| DESIGNED RUDDER ANGLE | 35.00 |
| ELAPSED TIME FROM THE ORDER TO DESIGNED RUDDER ANGLE | 25.20 |
| MEASURED RUDDER ANGLE | 35.00 |
| DISTANCE FROM PIVOTING POINT TO SHIPS GRAVITY | 100.00 |
| LENGTH BETWEEN PERPENDICULARS | 320.00 |

| | | |
|---|---|---|
| UNIT FOR OUT PUT | 0 | METRIC |
| INDICATION OF DRAWING | 1 | DRAW |
| DRAWING SCALE | 4 | A4 SIZE |
| INDICATION OF TURNING | 0 | BOTH |
| INDICATION OF RIGHT OR LEFT | 1 | PORT |
| NON-CANADIAN DATA | 1 | CONSIDER |

### *** SPEED DATA ***

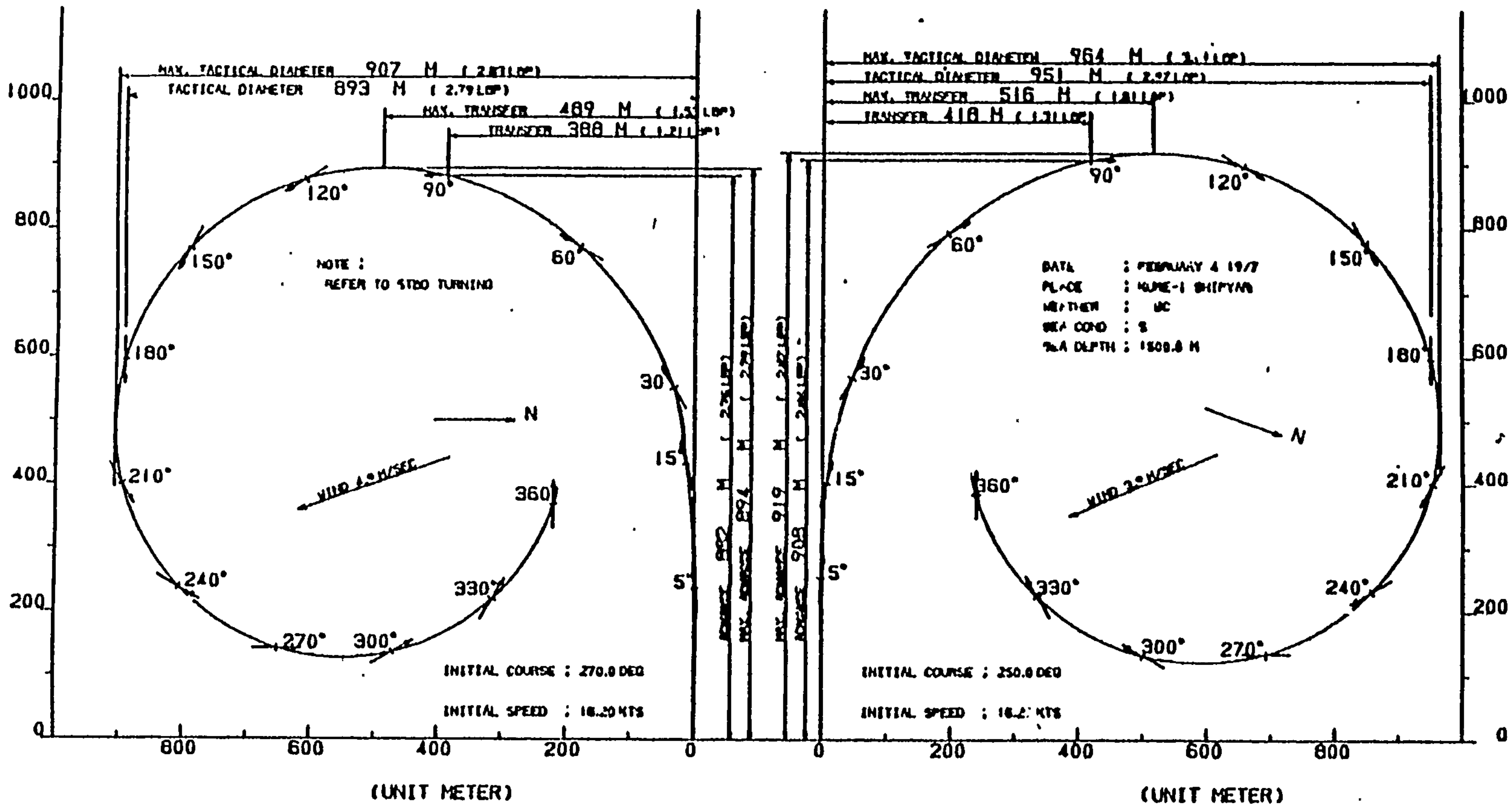
MEASURED SPACE OF SPEED 40.0

DISTANCE FROM C.L. TO MEAN MEASURED BOARD 47.3

| | (MINUTE) | (SECOND) | (ELAPSED TIME) |
|---|---|---|---|
| 1 | 0 | 10.00 | 4.90 |
| 2 | 0 | 20.00 | 5.00 |
| 3 | 0 | 30.00 | 5.30 |
| 4 | 0 | 40.00 | 5.50 |
| 5 | 0 | 50.00 | 5.70 |
| 6 | 1 | 0.0 | 6.00 |
| 7 | 1 | 20.00 | 6.50 |
| 8 | 1 | 40.00 | 7.20 |
| 9 | 2 | 0.0 | 8.10 |
| 10 | 2 | 30.00 | 9.30 |
| 11 | 3 | 0.0 | 10.70 |
| 12 | 3 | 30.00 | 12.10 |
| 13 | 4 | 0.0 | 13.50 |
| 14 | 4 | 30.00 | 14.70 |
| 15 | 5 | 0.0 | 15.70 |
| 16 | 5 | 30.00 | 16.60 |
| 17 | 6 | 0.0 | 17.40 |
| 18 | 6 | 30.00 | 18.10 |
| 19 | 7 | 0.0 | 18.80 |
| 20 | 7 | 30.00 | 19.20 |
| 21 | 8 | 0.0 | 19.70 |
| 22 | 8 | 30.00 | 20.00 |
| 23 | 9 | 0.0 | 20.30 |
| 24 | 9 | 30.30 | 20.60 |
| 25 | 10 | 0.0 | 20.90 |
| 26 | 10 | 30.00 | 21.20 |
| 27 | 11 | 0.0 | 21.40 |
| 28 | 11 | 30.00 | 21.60 |
| 29 | 12 | 0.0 | 21.80 |
| 30 | 12 | 30.00 | 22.00 |
| 31 | 13 | 0.0 | 22.20 |
| 32 | 13 | 30.00 | 22.30 |

| NO | TIME (SEC) | MEASURED SPEED (M/SEC) | CORR. SPEED (M/SEC) | ANGULAR VELOCITY | SHIP'S POSITION (ADVANCE) | SHIP'S POSITION (TRANSFER) | TURNING ANGLE (DEG) |
|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 8.160 | 8.162 | 0.0 | 0.0 | 0.0 | 0.00 |
| 2 | 5.0 | 8.183 | 8.226 | 0.000923 | 40.9 | 0.4 | 0.16 |
| 3 | 10.0 | 8.163 | 8.259 | 0.002028 | 82.2 | 1.0 | 0.85 |
| 4 | 15.0 | 8.102 | 8.238 | 0.002873 | 123.5 | 1.6 | 1.67 |
| 5 | 20.0 | 8.060 | 8.174 | 0.003669 | 164.6 | 1.8 | 2.72 |
| 6 | 25.0 | 7.821 | 8.021 | 0.004221 | 205.1 | 1.6 | 3.93 |
| 7 | 30.0 | 7.547 | 7.766 | 0.004637 | 244.7 | 0.8 | 5.26 |
| 8 | 35.0 | 7.406 | 7.628 | 0.004706 | 283.2 | -0.9 | 6.60 |
| 9 | 40.0 | 7.273 | 7.514 | 0.005091 | 321.0 | -3.2 | 8.06 |
| 10 | 45.0 | 7.147 | 7.424 | 0.005862 | 358.4 | -6.0 | 9.74 |
| 11 | 50.0 | 7.018 | 7.373 | 0.007512 | 395.4 | -9.3 | 11.89 |
| 12 | 55.0 | 6.845 | 7.386 | 0.011424 | 432.6 | -12.3 | 15.17 |
| 13 | 60.0 | 6.667 | 7.372 | 0.014919 | 470.1 | -16.1 | 19.44 |
| 14 | 65.0 | 6.520 | 7.261 | 0.015680 | 506.9 | -22.3 | 23.93 |
| 15 | 70.0 | 6.404 | 7.260 | 0.018265 | 543.5 | -30.4 | 29.16 |
| 16 | 75.0 | 6.285 | 6.924 | 0.013523 | 577.4 | -43.0 | 33.04 |
| 17 | 80.0 | 6.154 | 6.775 | 0.013140 | 609.2 | -57.2 | 36.80 |
| 18 | 85.0 | 5.958 | 6.613 | 0.013008 | 639.4 | -73.0 | 40.53 |
| 19 | 90.0 | 5.821 | 6.430 | 0.012876 | 667.9 | -90.2 | 44.72 |
| 20 | 95.0 | 5.648 | 6.250 | 0.012744 | 694.4 | -108.6 | 47.87 |
| 21 | 100.0 | 5.479 | 6.076 | 0.012612 | 719.2 | -128.0 | 51.48 |
| 22 | 105.0 | 5.323 | 5.923 | 0.012480 | 742.1 | -148.3 | 55.06 |
| 23 | 110.0 | 5.194 | 5.778 | 0.012348 | 763.3 | -169.4 | 58.60 |
| 24 | 115.0 | 5.063 | 5.646 | 0.012216 | 782.7 | -191.2 | 62.10 |
| 25 | 120.0 | 4.938 | 5.510 | 0.012084 | 800.4 | -213.5 | 65.56 |
| 26 | 125.0 | 4.823 | 5.389 | 0.011952 | 816.5 | -236.3 | 68.98 |
| 27 | 130.0 | 4.712 | 5.271 | 0.011820 | 830.9 | -259.5 | 72.37 |
| 28 | 135.0 | 4.604 | 5.157 | 0.011688 | 843.7 | -283.0 | 75.72 |
| 29 | 140.0 | 4.500 | 5.046 | 0.011556 | 854.9 | -306.6 | 79.03 |
| 30 | 145.0 | 4.399 | 4.939 | 0.011424 | 864.6 | -330.3 | 82.30 |
| 31 | 150.0 | 4.301 | 4.835 | 0.011292 | 872.8 | -354.0 | 85.53 |
| 32 | 155.0 | 4.199 | 4.727 | 0.011160 | 879.5 | -377.6 | 88.73 |
| 33 | 160.0 | 4.101 | 4.639 | 0.011382 | 885.1 | -401.0 | 91.99 |
| 34 | 165.0 | 4.005 | 4.535 | 0.011192 | 889.2 | -424.3 | 95.20 |
| 35 | 170.0 | 3.913 | 4.415 | 0.010604 | 891.9 | -447.1 | 98.24 |
| 36 | 175.0 | 3.824 | 4.309 | 0.010256 | 893.2 | -469.5 | 101.17 |
| 37 | 180.0 | 3.738 | 4.213 | 0.010030 | 893.5 | -491.4 | 104.05 |
| 38 | 185.0 | 3.657 | 4.121 | 0.009795 | 892.7 | -512.7 | 106.85 |
| 39 | 190.0 | 3.581 | 4.035 | 0.009592 | 890.8 | -533.6 | 109.60 |
| 40 | 195.0 | 3.509 | 3.959 | 0.009516 | 888.1 | -554.0 | 112.33 |
| 41 | 200.0 | 3.439 | 3.884 | 0.009404 | 884.6 | -573.8 | 115.02 |
| 42 | 205.0 | 3.371 | 3.811 | 0.009292 | 880.2 | -593.1 | 117.68 |
| 43 | 210.0 | 3.306 | 3.741 | 0.009706 | 875.1 | -611.8 | 120.32 |
| 44 | 215.0 | 3.242 | 3.681 | 0.009289 | 869.3 | -630.1 | 122.98 |
| 45 | 220.0 | 3.180 | 3.615 | 0.009187 | 862.8 | -647.7 | 125.61 |
| 46 | 225.0 | 3.122 | 3.552 | 0.009086 | 855.7 | -664.8 | 128.22 |
| 47 | 230.0 | 3.066 | 3.492 | 0.008998 | 847.9 | -681.2 | 130.80 |
| 48 | 235.0 | 3.013 | 3.432 | 0.008855 | 839.6 | -697.0 | 133.33 |
| 49 | 240.0 | 2.963 | 3.375 | 0.008713 | 830.8 | -712.2 | 135.83 |
| 50 | 245.0 | 2.917 | 3.322 | 0.008570 | 821.5 | -726.8 | 138.28 |
| 51 | 250.0 | 2.874 | 3.272 | 0.008430 | 811.7 | -740.7 | 140.70 |
| 52 | 255.0 | 2.832 | 3.223 | 0.008255 | 801.4 | -753.9 | 143.06 |
| 53 | 260.0 | 2.793 | 3.174 | 0.008063 | 790.8 | -766.6 | 145.37 |
| 54 | 265.0 | 2.756 | 3.125 | 0.007812 | 779.9 | -778.5 | 147.61 |
| 55 | 270.0 | 2.721 | 3.086 | 0.007723 | 768.6 | -789.9 | 149.82 |

旋回力試験




PORT TURNING

| | 90 DEG | 180 DEG |
|---|---|---|
| ELAPSED TIME : | 2'-37.0" | 5'-30.6" |
| DISTANCE : | 1043 M | 1869M |

STARBOARD TURNING

| | 90 DEG | 180 DEG |
|---|---|---|
| ELAPSED TIME : | 2'-37.2" | 5'-35.0" |
| DISTANCE : | 1606 M | 1740M |

| | PORT | STARBOARD |
|---|---|---|
| LOADING CONDITION | FULL | FULL |
| ENGINE OUT PUT | M.C.R. | M.C.R. |
| ACTUAL RUDDER ANGLE | 35.0 DEG | 35.0 DEG |
| THE TIME TAKEN TO CHANGE 35 DEG. AT RUDDER HEAD | 25.2 SEC | 23.0 SEC |

Port turning:

| TURNING ANGLE (DEGREE) | 360 | 330 | 300 | 270 | 240 | 210 | 180 | 150 | 120 | 90 | 60 | 30 | 15 | 5 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THE TIME REQUIRED (MIN - SEC) | 13 - 19.8 | 11 - 57.2 | 10 - 40.4 | 9 - 22.0 | 8 - 5.6 | 6 - 51.0 | 5 - 36.6 | 4 - 20.4 | 3 - 29.4 | 2 - 37.0 | 1 - 52.0 | 1 - 11.0 | 0 - 54.0 | 0 - 29.0 | 0 - 0.0 |
| SHAFT R.P.M. | 72.[illegible] | 72.5 | 72.0 | 72.0 | 72.0 | 73.0 | 74.0 | 75.0 | 77.0 | 79.0 | 82.0 | 82.0 | 83.0 | 83.0 | 83.0 |

Starboard turning:

| TURNING ANGLE (DEGREE) | 0 | 5 | 15 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THE TIME REQUIRED (MIN - SEC) | 0 - 0.0 | 0 - 31.0 | 0 - 49.6 | 1 - 12.2 | 1 - 52.4 | 2 - 37.2 | 3 - 30.0 | 4 - 30.2 | 5 - 33.6 | 6 - 45.0 | 8 - 0.0 | 9 - 17.2 | 10 - 36.0 | 11 - 56.2 | 13 - 15.0 |
| SHAFT R.P.M. | 83.0 | 83.4 | 81.0 | 80.5 | 78.8 | 77.5 | 75.0 | 73.6 | 72.0 | 72.9 | 73.0 | 71.0 | 71.0 | 71.0 | 71.0 |

### *** INPUT DATA FOR CRASH STOP ASTERN AND AHEAD TEST ***

----- CRASH STOP ASTERN TEST -----

| | | | |
|---|---|---|---|
| DATE | FEBRUARY 20, 1977 | | |
| PLACE | KURE-1 SHIP YARD | | |
| COND. | FULL LOADED CONDITION | | |
| WEATHER | 0 | | |
| SEA COND. | 4 | | |
| SEA DEPTH | | 7000.00 | |
| R. WIND DIRECTION | | 120.00 | |
| R. WIND VELOCITY | | 7.00 | |
| INITIAL SPEED | | 16.20 | |
| INITIAL COURSE | | 250.00 | |
| INITIAL RPM | | 84.00 | |
| SETTLED SPEED | | -4.50 | |
| SETTLED RPM | | 25.00 | |
| UNIT FOR OUT PUT | | 0 | METRIC |
| INDICATION OF DRAWING | | 1 | DRAW |
| DRAWING SCALE | | 4 | A4 SIZE |
| INDICATION OF TEST | | 0 | CRASH STOP ASTERN TEST |
| NON CANADIAN DATA | | 1 | CONSIDER |

DATA NAME FOR ENGINE PART (MIN.) (SECOND)

| | | |
|---|---|---|
| AHEAD VALVE SHUT | 0 — | 5.00 |
| ASTERN VALVE OPEN | 0 — | 0.00 |
| SHAFT STOP AND START | 0 — | 14.00 |
| ASTERN RPM SETTLED | 4 — | 20.00 |
| | 0 — | 0.0 |

前後進試験

### *** SPEED DATA ***

MEASURED SPACE OF SPEED 40.0

DISTANCE FROM C.L. TO MEAN MEASURED BOARD 27.0

| | (MINUTE) | (SECOND) | (ELAPSED TIME) |
|---|---|---|---|
| 1 | 0 | 10.00 | 4.00 |
| 2 | 0 | 30.00 | 5.60 |
| 3 | 1 | 0.0 | 5.50 |
| 4 | 1 | 30.00 | 7.00 |
| 5 | 2 | 0.0 | 8.50 |
| 6 | 2 | 30.00 | 10.50 |
| 7 | 3 | 0.0 | 16.00 |
| 8 | 3 | 30.00 | 19.00 |
| 9 | 4 | 0.0 | 23.50 |
| 10 | 4 | 30.00 | 28.50 |
| 11 | 5 | 0.0 | 32.00 |
| 12 | 5 | 30.00 | 37.00 |
| 13 | 6 | 0.0 | 47.00 |
| 14 | 6 | 30.00 | -45.00 |
| 15 | 7 | 0.0 | -43.00 |
| 16 | 7 | 30.00 | -41.60 |
| 17 | 8 | 0.0 | -40.00 |
| 18 | 8 | 30.00 | -38.60 |
| 19 | 9 | 0.0 | -35.50 |
| 20 | 9 | 30.00 | -32.00 |
| 21 | 10 | 0.0 | -29.70 |
| 22 | 10 | 30.00 | -26.00 |
| 23 | 11 | 0.0 | -22.00 |
| 24 | 11 | 30.00 | -20.00 |
| 25 | 12 | 0.0 | -18.00 |
| 26 | 12 | 30.00 | -15.70 |
| 27 | 13 | 0.0 | -13.50 |
| 28 | 13 | 30.00 | -10.20 |
| 29 | 14 | 0.0 | -10.00 |
| 30 | 14 | 30.00 | -10.00 |

### *** HEAD. ANGLE DATA ***

| | (MINUTE) | (SECOND) | (HEAD. ANGLE) |
|---|---|---|---|
| 1 | 0 | 10.00 | 250.00 |
| 2 | 0 | 20.00 | 253.00 |
| 3 | 0 | 30.00 | 255.00 |
| 4 | 0 | 40.00 | 257.00 |
| 5 | 0 | 50.00 | 260.00 |
| 6 | 1 | 0.0 | 266.00 |
| 7 | 1 | 30.00 | 270.00 |
| 8 | 2 | 0.0 | 276.00 |
| 9 | 2 | 30.00 | 281.50 |
| 10 | 3 | 0.0 | 289.00 |
| 11 | 3 | 30.00 | 295.50 |
| 12 | 4 | 0.0 | 302.00 |
| 13 | 4 | 30.00 | 307.00 |
| 14 | 5 | 0.0 | 309.50 |
| 15 | 5 | 30.00 | 311.00 |
| 16 | 6 | 0.0 | 312.00 |
| 17 | 6 | 30.00 | 312.30 |
| 18 | 7 | 0.0 | 312.00 |
| 19 | 7 | 30.00 | 311.90 |
| 20 | 8 | 0.0 | 311.00 |
| 21 | 8 | 30.00 | 309.70 |
| 22 | 9 | 0.0 | 307.20 |
| 23 | 9 | 30.00 | 305.00 |
| 24 | 10 | 0.0 | 303.00 |
| 25 | 11 | 0.0 | 301.20 |
| 26 | 12 | 0.0 | 290.20 |
| 27 | 13 | 0.0 | 287.00 |
| 28 | 14 | 0.0 | 284.00 |
| 29 | 15 | 0.0 | 282.00 |
| 30 | 0 | 0.0 | 0.0 |

--- RESULT OF CRASH STOP ASTERN TEST ---

| | |
|---|---|
| DATE | FEBRUARY 20, 1977 |
| PLACE | KURE-1 SHIP YARD |
| LOAD COND | FULL LOADED CONDITION |
| WEATHER | D |
| SEA COND | 4 |
| SEA DEPTH | 7000.0 M |
| INITIAL COURSE | 150.0 DEG |
| R. WIND | [illegible] DEG 7.[illegible] M/SEC |

| | |
|---|---|
| INITIAL SPEED | 16.7 KTS |
| RPM | 84.0 |
| ASTERN SETTLED SPEED | -4.5 KTS |
| RPM | 25.0 |
| SHIP'S STOP | 6'-15.6" |

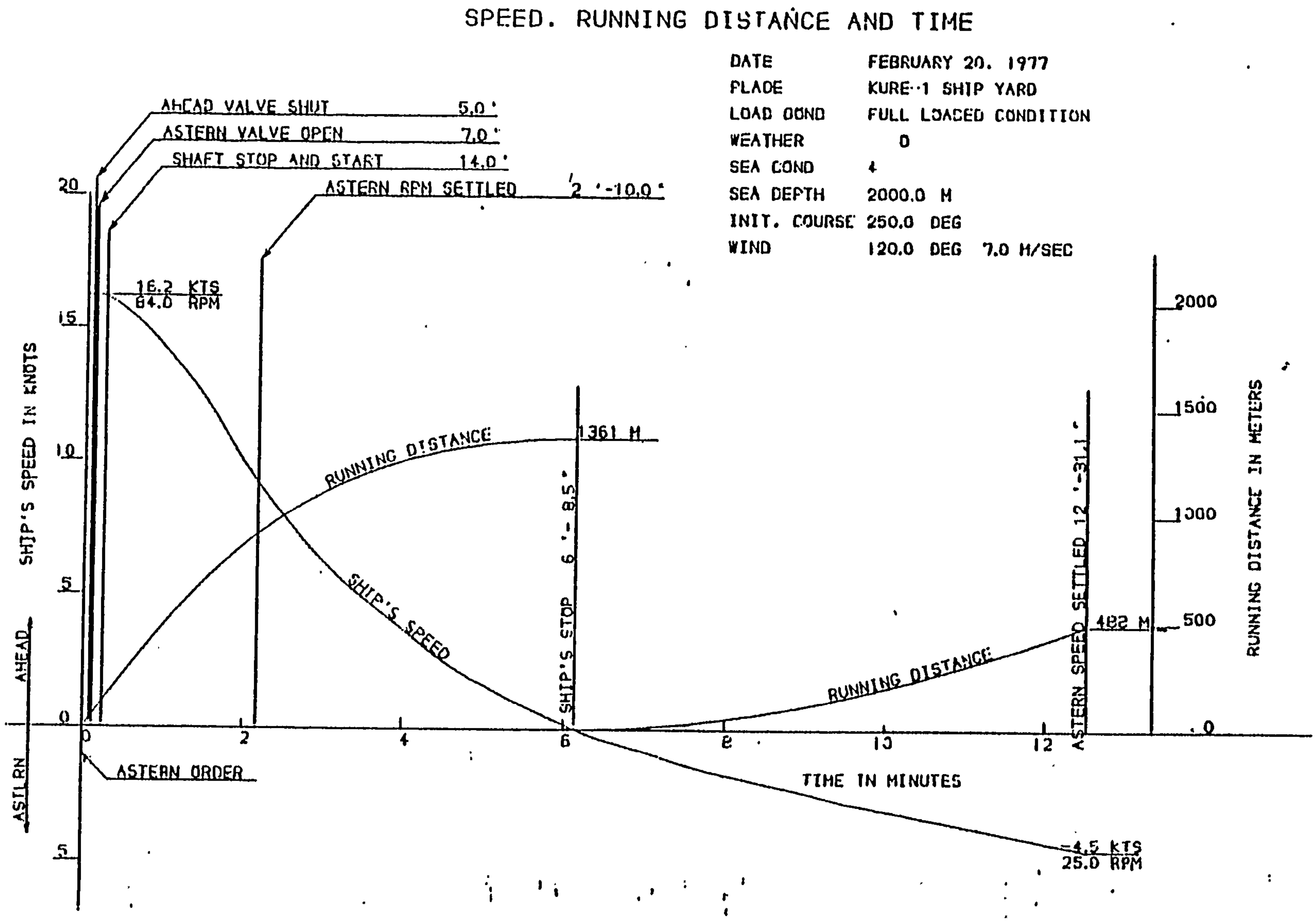
*** CALCULATION OF CRASH STOPASTERN TEST ***

| NO | TIME (SEC) | MEASURED SPEED (M/SEC) | CORR. SPEED (M/SEC) | ANGULAR VELOCITY | SHIP'S POSITION (ADVANCE) | SHIP'S POSITION (TRANSFER) |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 8.413 | 8.466 | 0.0 | 0.0 | 0.0 |
| 2 | 5.0 | 8.400 | 8.414 | 0.000524 | 42.2 | -0.1 |
| 3 | 10.0 | 8.33[illegible] | 8.340 | 0.000240 | 84.1 | -0.1 |
| 4 | 15.0 | 8.260 | 8.252 | -0.000053 | 125.6 | -0.1 |
| 5 | 20.0 | 8.116 | 8.17[illegible] | [illegible] | 166.6 | -0.2 |
| 6 | 25.0 | 8.07[illegible] | 8.076 | -0.000656 | 207.3 | -0.3 |
| 7 | 30.0 | 8.0[illegible] | 7.956 | -0.016478 | 246.3 | -2.1 |
| 8 | 35.0 | 7.960 | 7.808 | -0.003410 | 284.5 | -5.8 |
| 9 | 40.0 | 7.793 | 7.696 | -0.003571 | 323.0 | -10.2 |
| 10 | 45.0 | 7.6[illegible] | 7.561 | -0.004434 | 360.8 | -15.2 |
| 11 | 50.0 | 7.5[illegible] | 7.4[illegible] | [illegible] | 397.8 | -21.2 |
| 12 | 55.0 | 7.432 | 7.229 | -0.014928 | 433.1 | -28.8 |
| 13 | 60.0 | 7.273 | 7.116 | -0.006016 | 467.2 | -38.0 |
| 14 | 65.0 | 7.097 | 7.019 | -0.007899 | 501.1 | -48.0 |
| 15 | 70.0 | 6.871 | 6.807 | -0.002305 | 534.1 | -58.2 |
| 16 | 75.0 | 6.579 | 6.523 | -0.002016 | 565.8 | -68.4 |
| 17 | 80.0 | 6.243 | 6.192 | [illegible] | 596.0 | -78.4 |
| 18 | 85.0 | 5.947 | 5.889 | -0.002156 | 624.5 | -88.2 |
| 19 | 90.0 | 5.714 | 5.646 | -0.002543 | 651.7 | -97.9 |
| 20 | 95.0 | 5.521 | 5.451 | -0.007930 | 677.7 | -107.6 |
| 21 | 100.0 | 5.343 | 5.265 | -0.002258 | 702.7 | -117.3 |
| 22 | 105.0 | 5.172 | 5.090 | -0.003322 | 726.6 | -127.1 |
| 23 | 110.0 | 5.017 | 4.92[illegible] | -0.003590 | 749.6 | -137.0 |
| 24 | 115.0 | 4.858 | 4.756 | -0.003788 | 771.7 | -147.0 |
| 25 | 120.0 | 4.706 | 4.598 | -0.003986 | 792.8 | -157.0 |
| 26 | 125.0 | 4.558 | 4.441 | -0.004338 | 813.0 | -167.1 |
| 27 | 130.0 | 4.411 | 4.291 | -0.004443 | 832.3 | -177.4 |
| 28 | 135.0 | 4.281 | 4.150 | -0.004558 | 850.7 | -187.7 |
| 29 | 140.0 | 4.153 | 4.029 | -0.004626 | 868.4 | -198.0 |
| 30 | 145.0 | 3.996 | 3.883 | -0.004280 | 885.2 | -208.4 |

前後進試験

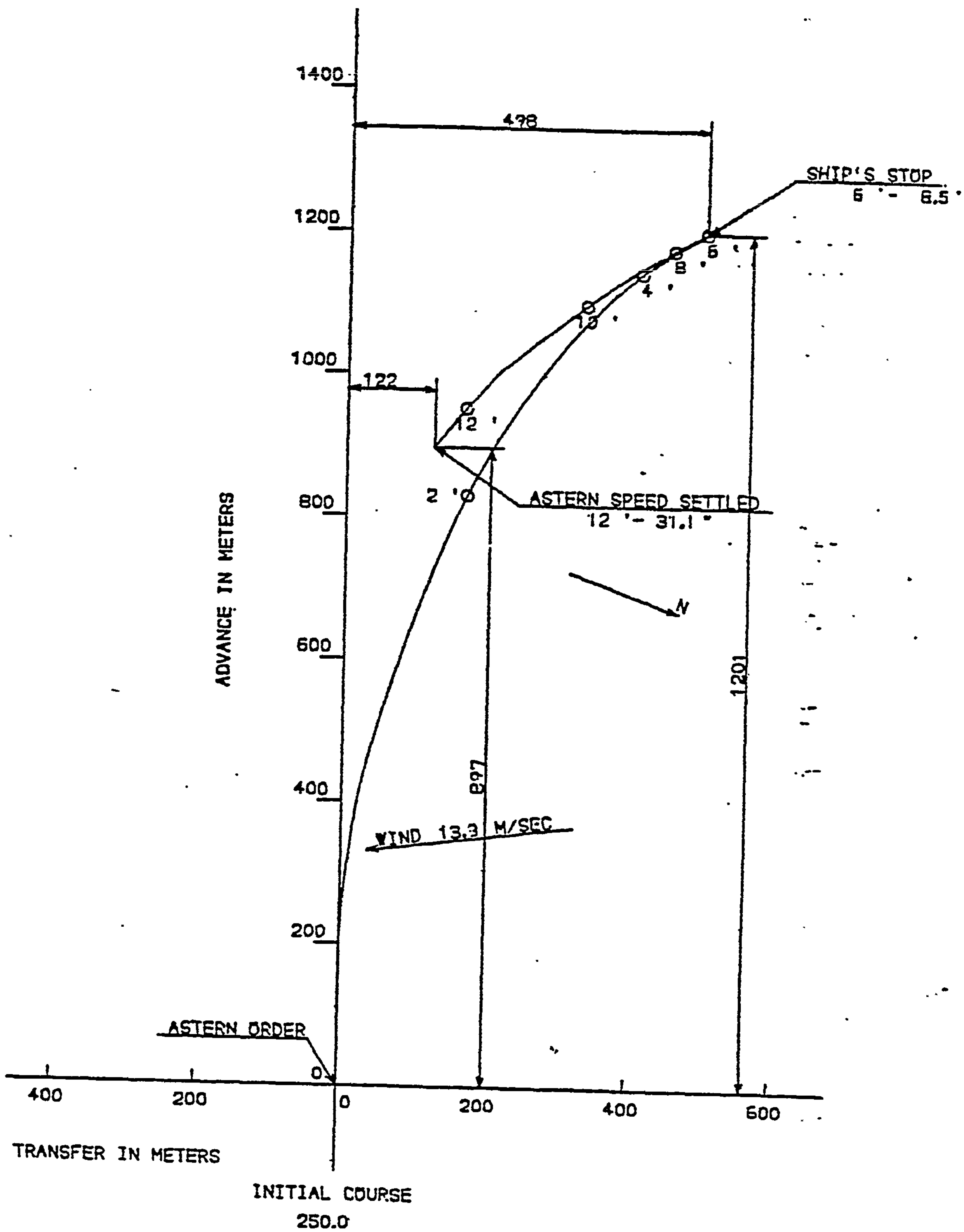
# 前後進試験

## RESULT OF CRASH STOP ASTERN TEST



# 前後進試験

## COURSE OF CRASH STOP ASTERN TEST



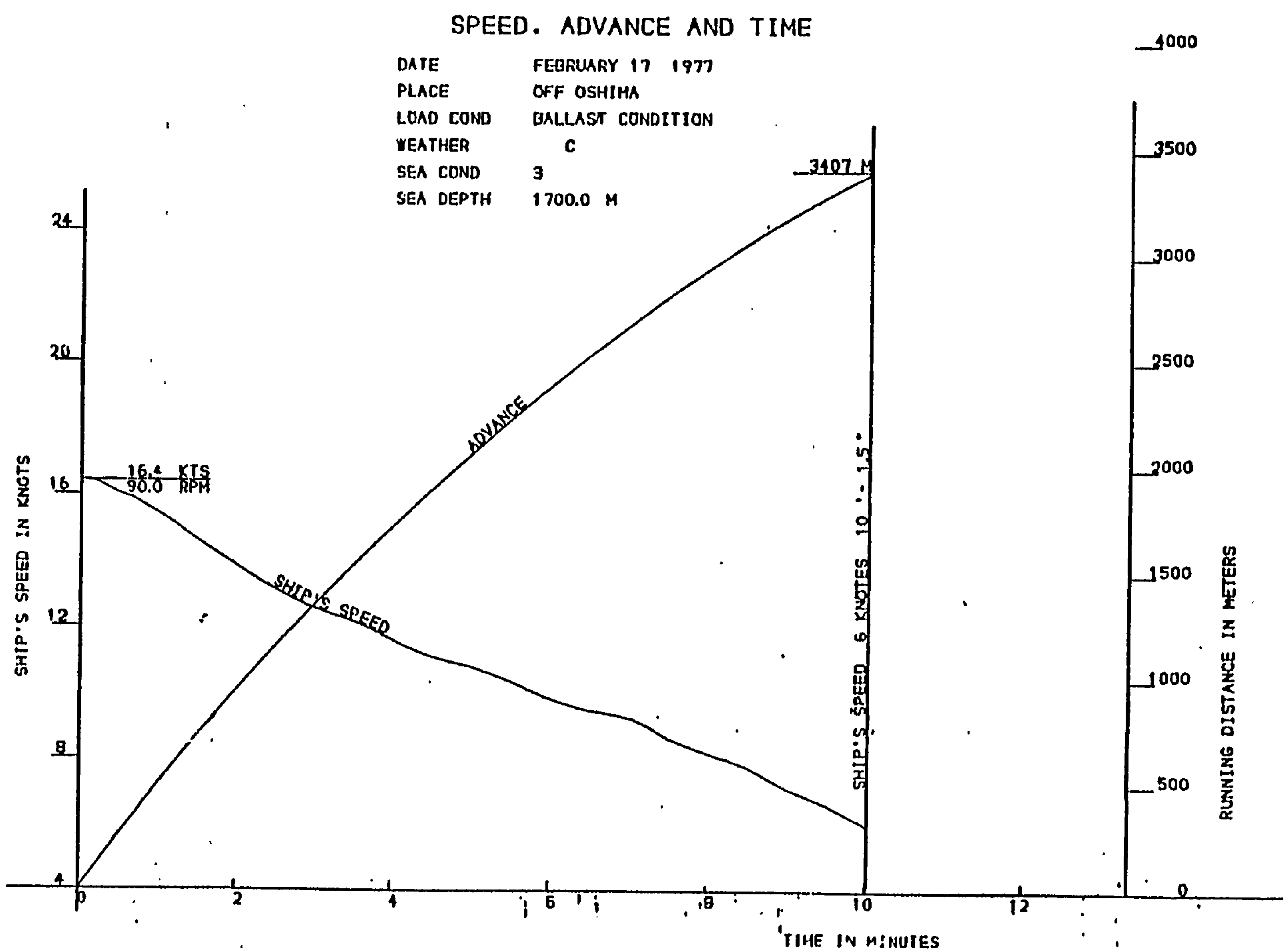
## RESULT OF STOPPING INERTIA TEST

| | |
|---|---|
| DATE | FEBRUARY 17 1977 |
| PLACE | OFF OSHIMA |
| LOAD COND | BALLAST CONDITION |
| WEATHER | C |
| SEA COND | 3 |
| SEA DEPTH | 1700.0 M |
| INITIAL COURSE | 120.0 DEG |
| R. WIND | 37.9 DEG 12.0 M/SEC |
| INITIAL SPEED | 16.4 KTS |
| RPM | 90.0 |
| SHIP'S SPEED | 6.0 KTS |
| ELAPSED TIME | 10'- 2.3" |

### *** CALCULATION OF STOPPING INERTIA TEST ***

| NO | TIME (SEC) | MEASURED SPEED (M/SEC) | CORR. SPEED (M/SEC) | ANGULAR VELOCITY | SHIP'S POSITION (ADVANCE) | SHIP'S POSITION (TRANSFER) |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 8.304 | 8.384 | 0.0 | 0.0 | 0.0 |
| 2 | 5.0 | 8.263 | 8.154 | -0.004052 | 41.3 | 1.1 |
| 3 | 10.0 | 8.163 | 8.079 | -0.003129 | 81.9 | 1.4 |
| 4 | 15.0 | 8.078 | 8.018 | -0.002207 | 122.2 | 1.2 |
| 5 | 20.0 | 8.000 | 7.965 | -0.001284 | 162.1 | 0.6 |
| 6 | 25.0 | 7.974 | 7.899 | -0.000926 | 201.8 | -0.2 |
| 7 | 30.0 | 7.843 | 7.819 | -0.000891 | 241.0 | -1.1 |
| 8 | 35.0 | 7.689 | 7.666 | -0.000851 | 279.7 | -2.3 |
| 9 | 40.0 | 7.547 | 7.525 | -0.000823 | 317.7 | -3.5 |
| 10 | 45.0 | 7.477 | 7.463 | -0.000868 | 355.1 | -4.9 |
| 11 | 50.0 | 7.407 | 7.384 | -0.000883 | 392.2 | -6.4 |
| 12 | 55.0 | 7.339 | 7.316 | -0.000880 | 428.9 | -8.1 |
| 13 | 60.0 | 7.273 | 7.250 | -0.000859 | 465.3 | -9.9 |
| 14 | 65.0 | 7.215 | 7.194 | -0.000764 | 501.3 | -11.9 |
| 15 | 70.0 | 7.163 | 7.143 | -0.000721 | 537.1 | -14.0 |
| 16 | 75.0 | 7.117 | 7.099 | -0.000678 | 572.6 | -16.2 |
| 17 | 80.0 | 7.078 | 7.061 | -0.000635 | 608.0 | -18.5 |
| 18 | 85.0 | 7.045 | 7.030 | -0.000544 | 643.1 | -20.8 |
| 19 | 90.0 | 7.018 | 7.014 | -0.000149 | 678.1 | -23.3 |
| 20 | 95.0 | 6.966 | 6.966 | 0.0 | 713.0 | -25.7 |
| 21 | 100.0 | 6.920 | 6.920 | 0.0 | 747.6 | -28.1 |
| 22 | 105.0 | 6.878 | 6.878 | 0.0 | 782.0 | -30.5 |
| 23 | 110.0 | 6.841 | 6.841 | 0.0 | 816.2 | -32.9 |
| 24 | 115.0 | 6.808 | 6.808 | 0.0 | 850.3 | -35.3 |
| 25 | 120.0 | 6.780 | 6.780 | 0.0 | 884.2 | -37.7 |
| 26 | 125.0 | 6.761 | 6.761 | 0.0 | 917.9 | -40.0 |
| 27 | 130.0 | 6.742 | 6.742 | 0.0 | 951.6 | -42.4 |
| 28 | 135.0 | 6.723 | 6.723 | 0.0 | 985.2 | -44.7 |
| 29 | 140.0 | 6.707 | 6.707 | 0.0 | 1018.7 | -47.1 |
| 30 | 145.0 | 6.689 | 6.689 | 0.0 | 1052.1 | -49.4 |
| 31 | 150.0 | 6.667 | 6.667 | 0.0 | 1005.4 | -51.8 |
| 32 | 155.0 | 6.638 | 6.638 | 0.0 | 1118.6 | -54.1 |
| 33 | 160.0 | 6.605 | 6.605 | 0.0 | 1151.6 | -56.4 |
| 34 | 165.0 | 6.568 | 6.568 | 0.0 | 1184.5 | -58.7 |

前進惰力試

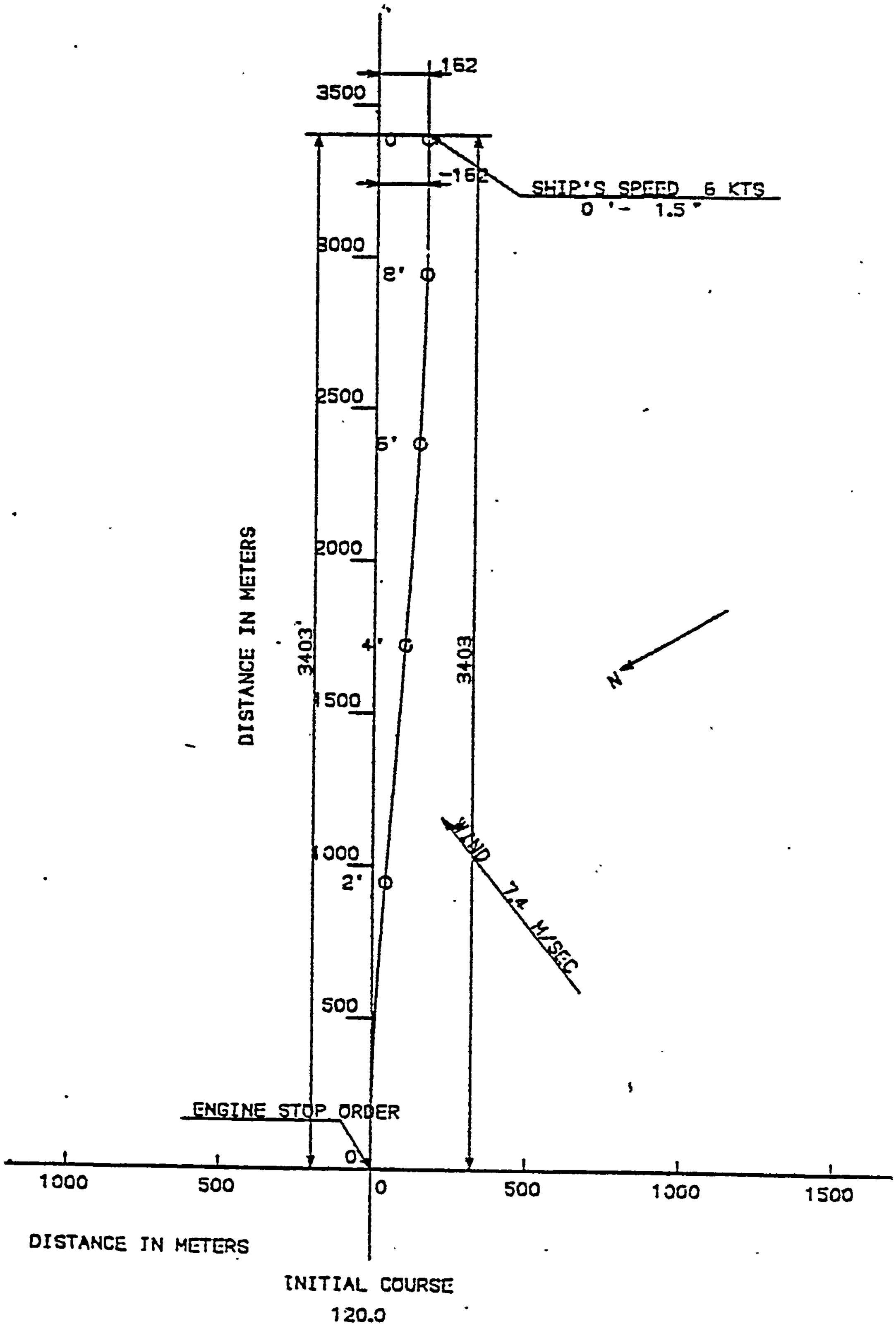



RESULT OF STOPPING INERTIA TEST

前進惰力試験

# 前進惰力試験

## COURSE OF STOPPING INERTIA TEST



*** INPUT DATA FOR ZIG-ZAG TEST ***

| | | | |
|---|---|---|---|
| DATE | MARCH 9, 1977 | | |
| PLACE | KURE - 1 OFFICE | | |
| COND. | BALLAST CONDITION | | |
| WEATHER | B | | |
| SEA COND. | 3 | | |
| SEA DEPTH | 1500.00 | | |
| R. WIND DIRECTION | -90.00 | | |
| R. WIND VELOCITY | 20.00 | | |
| INITIAL COURSE | 220.00 | | |
| INITIAL SPEED | 14.00 | | |
| L B P | 94.00 | | |
| INDICATION OF DATA | | 0 | USING INPUT DATA AS IT IS |
| INDICATION OF DRAWING | | 0 | NOT DRAW |
| DRAWING SCALE | | 0 | A0 SIZE |

ANGLE VELOCITY DATA

ANGL2 = 0.9833
ANGL4 = -1.2833
ANGL6 = 1.4267

*** RUDDER ANGLE DATA ***

| | (MINUTE) | (SECOND) | (REDDER ANGLE) |
|---|---|---|---|
| 1 | 0 | 0.0 | 0.0 |
| 2 | 0 | 5.80 | 15.00 |
| 3 | 0 | 23.00 | 15.00 |
| 4 | 0 | 32.80 | -15.00 |
| 5 | 0 | 84.00 | -15.00 |
| 6 | 0 | 93.40 | 15.00 |
| 7 | 0 | 141.80 | 15.00 |
| 8 | 0 | 152.40 | -15.00 |
| 9 | 0 | 200.00 | -15.00 |

*** SPEED DATA ***

| | (MINUTE) | (SECOND) | (KNOT) |
|---|---|---|---|
| 1 | 0 | 0.0 | 25.80 |
| 2 | 2 | 0.0 | 24.45 |
| 3 | 4 | 0.0 | 23.50 |
| 4 | 6 | 0.0 | 23.00 |
| 5 | 7 | 10.00 | 22.85 |
| 6 | 22 | 0.0 | 18.00 |

*** HEAD. ANGLE DATA ***

| | (MINUTE) | (SECOND) | (HEAD. ANGLE) |
|---|---|---|---|
| 1 | 0 | 0.0 | 0.0 |
| 2 | 0 | 41.50 | 30.00 |
| 3 | 0 | 100.00 | -28.00 |
| 4 | 0 | 158.30 | 31.60 |
| 5 | 0 | 0.0 | 0.0 |
| 6 | 0 | 0.0 | 0.0 |

- RESULT OF ZIG-ZAG TEST -

| | |
|---|---|
| DATE | MARCH 9, 1977 |
| PLACE | KUAE - 1 OFFICE |
| LOAD COND | BALLAST CONDITION |
| WEATHER | B |
| SEA COND | 3 |
| SEA DEPTH | 1500.0 M |
| INITIAL COURSE | 220.0 DEG |
| INITIAL SPEED | 14.0 KTS |

A. WIND -90.0 DEG 20.0 M/SEC

LENGTH BETWEEN PERPENDICULARS 94.00 M

MANEUVERABILITY

| | |
|---|---|
| K 4 (1/SEC) | 6.14402 |
| K68 (1/SEC) | 0.10086 |
| KM (1/SEC) | 0.12244 |
| T4 (SEC) | 31.933 |
| T68 (SEC) | 17.942 |
| TM (SEC) | 24.938 |
| DELTA A (DEG) | 0.89892 |

(VS BASE)

| | |
|---|---|
| K | 1.5980 |
| T | 1.9107 |

操縦性指数
(連立方程式による)

Z 試験

# 記 号 の 説 明

## ABBREVIATION

| | | |
|---|---|---|
| DI SPT | : | displacement with appendige. |
| DISPT (HID) | : | Displacement without appendage. |
| APPEN | : | Appendage displacement. |
| DIFF | : | Displacement difference. |
| D.CORR. | : | Increase of displacement for one CM/inch sagging, in case of hogging this value means decrease of displacement. |
| T P C | : | Ton per one CM immersion. |
| T P I | : | Ton per one inch immersion. |
| L C G | : | Longitudinal center of gravity from midship. |
| L C B | : | Longitudinal center of buoyancy from midship. |
| L C F | : | Longitudinal Canter of floatation from midship. |
| K G | : | Vertical center of gravity above base line. |
| K B | : | Vertical center of buoyancy above base line. |
| T KM | : | Transverse metacenter above base line. |
| L KH | : | Longitudinal metacenter above base line. |
| G H | : | Height from center of gravity to transverse metacenter |
| CO M | : | Corrected height from center of gravity to transverse metacenter by free water effects. |
| G GO | : | Increase of center of gravity by free water effects. |
| A W | : | Hater plane area. |
| C W | : | Water plane area coefficient. |
| A H | : | **Midship sectional area.** |
| C M | : | Midship sectional area coefficient. |
| W.S A | : | Wetted surface area. |
| M T C | : | Moment to change trim one CM. |
| M T I | : | Moment to change trim one inch. |
| I | : | Moment of inertia. |
| I C L | : | Moment of inertia around center line. |
| I N A | : | Moment of inertia around neutral axis. |
| I / D | : | Propeller immersion ratio. |

# APPENDIX G

## CADS - PIPING DESIGN SYSTEM

# PART V. CADS Piping Design System

CONTENTS

## 1. CADS in Piping Design System

In piping design system, CADS is used for development of production engineering drawing for the purposes of:

(1) Modification of piping layout made by module and automated piping design system.

(2) Input of piping layout prepared by manually drafted sketch.

(3) Design of new module, and

(4) Modification of the module.

The data developed by CADS are transferred as a input data of pipe piece calculation program and material control program.

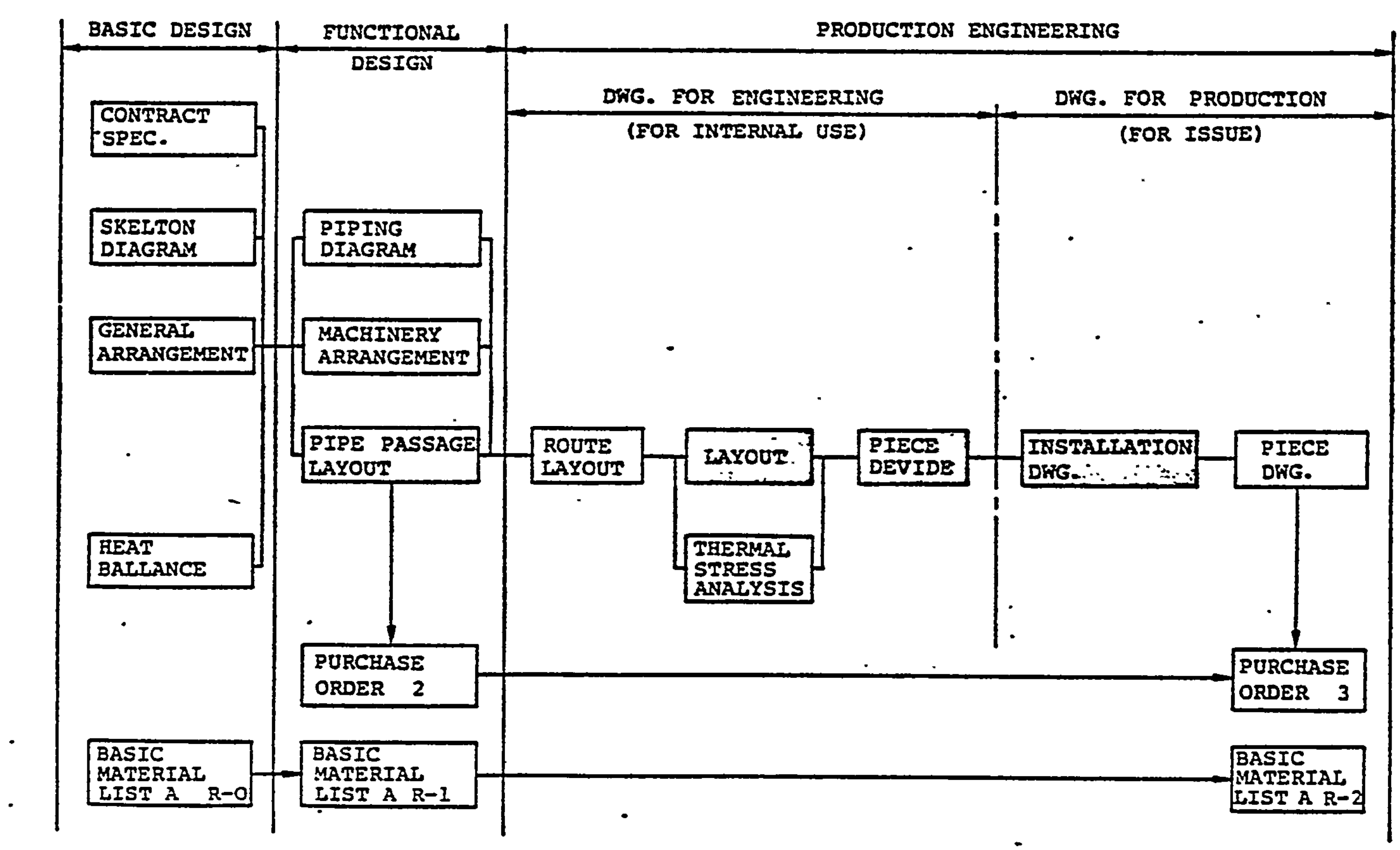



FIG 1.1 PROCESS OF PIPING DISIGN .(BY DWG)

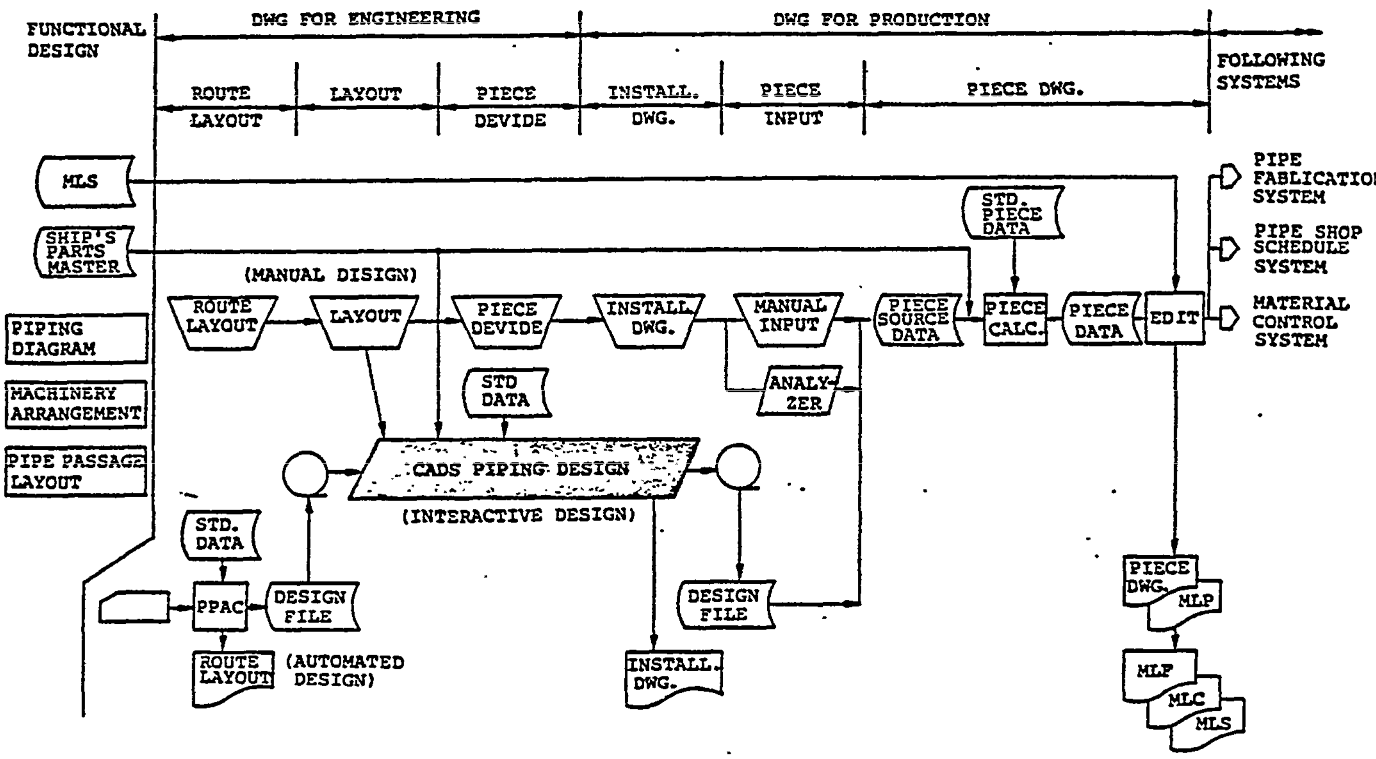



FIG 1·2 PIPING PRODUCTION ENGINEERING SYSTEM (ENG. RM)

## 2. Functions and Features of CADS Piping Design System

### 2.1 Functions of the System

(1) To use background drawings of hull structures and obstacles for piping, which are supplemented by transparent sheets, photographic techniques and additional hand-writing.

Among the background drawings, main hull structures (such as frames, longitudinals, decks) are registered and drawn by the system.

(2) To obtain tripartite drawings of pipe planning with plan, side and section views.

(3) To define pipe lines by indicating the start and end points and bent points.

Computer takes the following role by rough manually indicated data.

Running a pipe line in parallel with an axis..

Rounding pipe length

Setting bent piece standardized.

(4) To check intersection among pipes and others (tanks. hull constructions. etc.). by means of optional sections.

(5) To calculate the clearance between the designated pair of pipes.

(6) To set pipe fittings on pipe line.

Computer adjust the rough input data with Pen Analyzer to set it on pipe line and to round pipe piece length.

(7) To check the pipe piece dimension based on the fabrication standard.

(8) To design the shape of pipe support.

(9) To set the same shaped pipe lines and pipe supports corresponding to indicated portion that is designed already..

(10) To decide and draw leaders and characters such as pipe piece code, code of pipe supports, title of drawings.

(11) To provide data for pipe piece fabrication system and material control system.

## 2.2 Features of the System

1) Large Panel:

Optional sections of tripartite with optional scale are easily drawn out on large panel so as to check them in one-glance.

2) Easy Operation:

The designer does not required special knowledge of computer. The designer can operate the system through a few day's training.

3) Minimized Input Data:

(i) Simpel input operation of command and symbol with key-sheet and of X, Y, Z value with defined coordinate, either indication is performed with Pen-Analyzer.

(ii) Command and symbol operation is minimized with "Default" and "Modal" function.

(iii) The computer supplements the attributive data to input data of a few key words by means of the master data based on standardization.

4) Assured Quality of Drawings and Data to relevant System:

When the drawing is finished, every relevant data, such as dimension, fabrication practice, material and installation control, are defined simultaneously. So that the data missing, that is occured frequently in case of manual input, is eliminated.

5). Easy Maintenance:

Data, which have possibility of changing in accordance with ability or restriction of facility and condition of purchasing such as fabrication practice and dimensional table of outfittings, are registered in master file.

Therefore, it is not necessary to change programs to cope with alternation of condition.

Revision of the master file is rather easy than revision of program, *furthermore*, conversational revision measure of master file is established.

## 3. Design Procedure with CADS

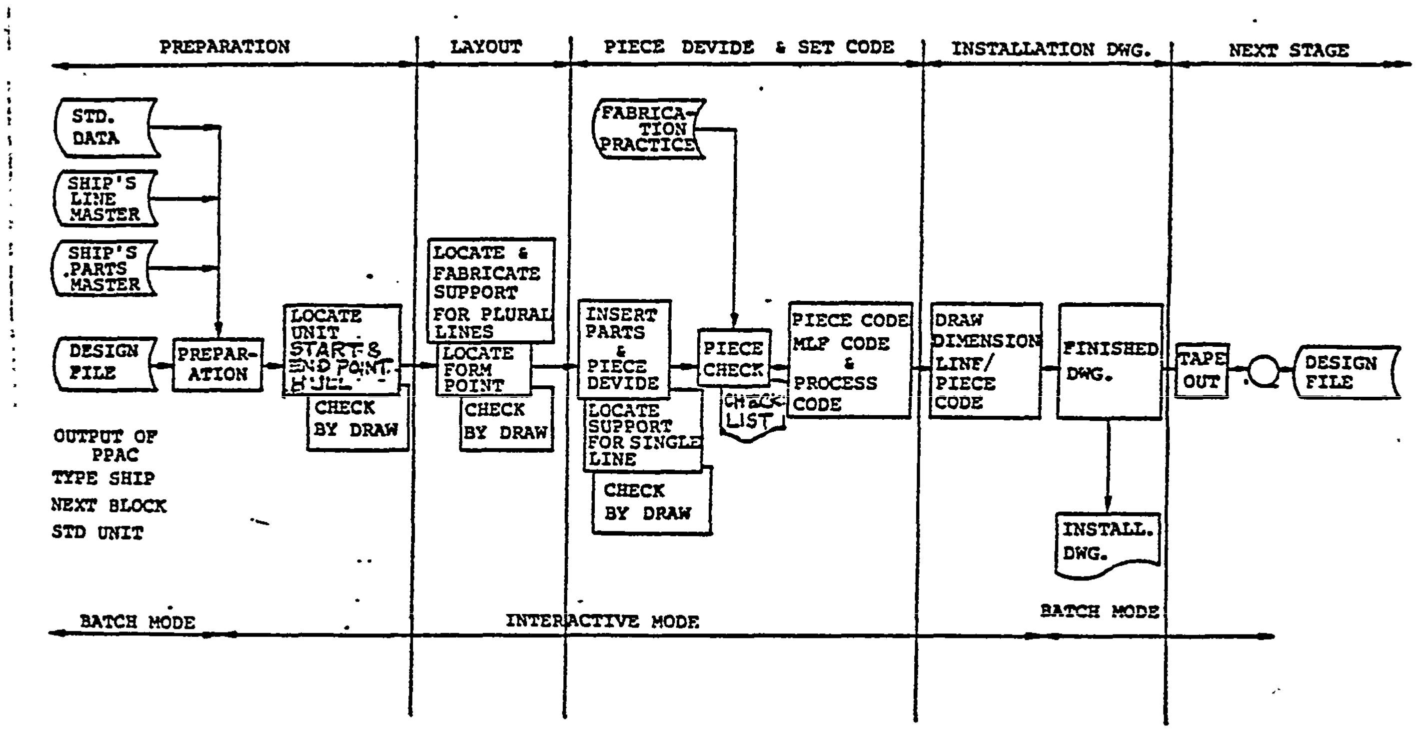



FIG 3.1 . OUTLINE PROCESS OF PIPING ENGINEERING WITH CADS

3.1 Step-1 Preparation

Locate Hull Unit & Start and End Point

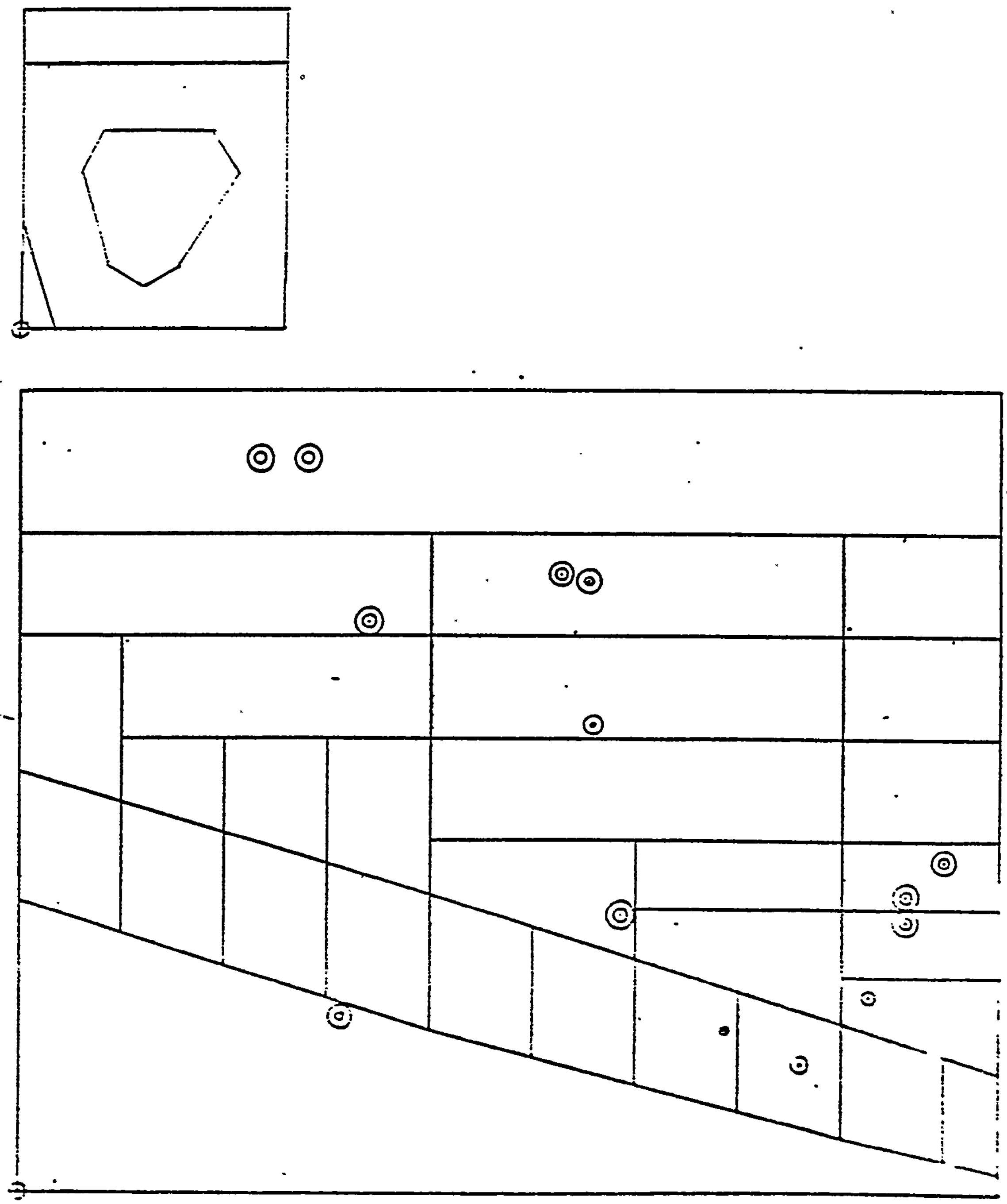


Fig. 3.2

3,2 Step-2 Layout

Locate Form

Locate & Fabricate Support

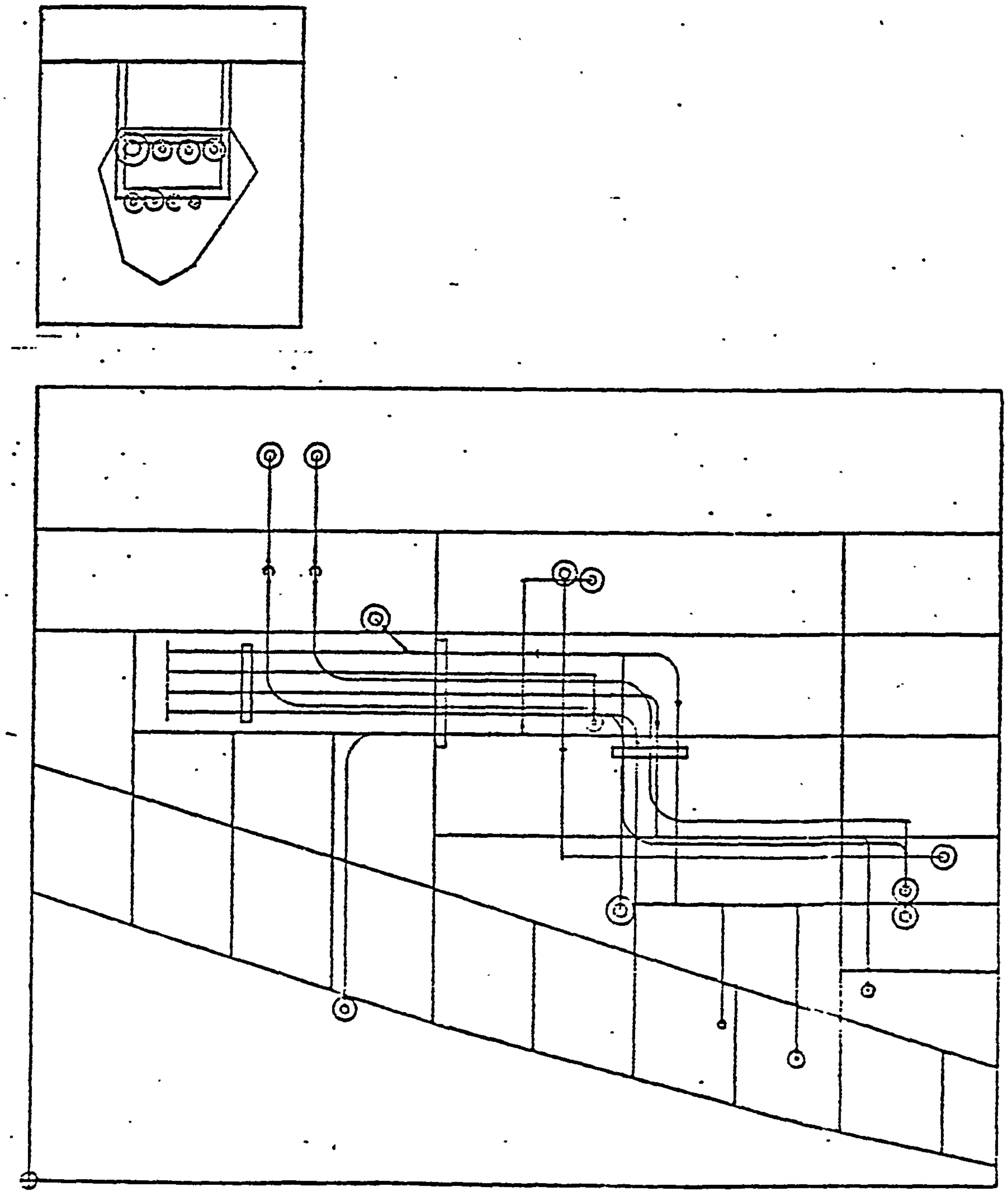
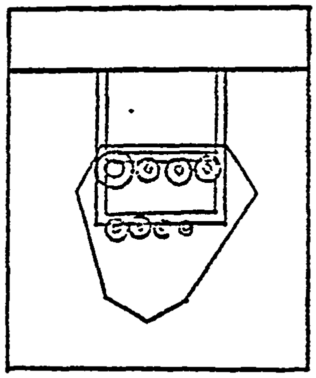


Fig. 3.3

3:3 Step-3 Piece Divide

Insert Parts & Piece Devide



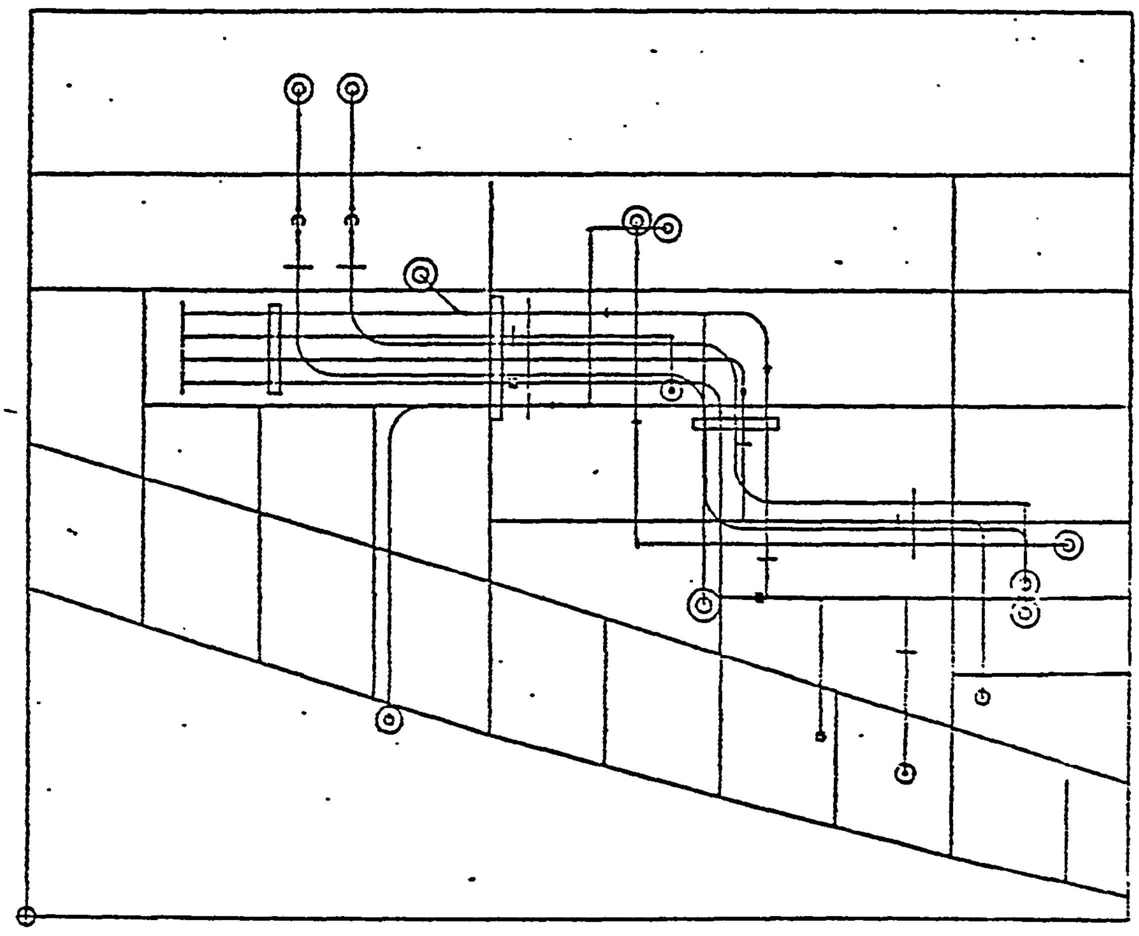


Fig. 3.4

Piece Check

Table 3.1

```
**PIECE CHECK*

**AS03210

E042 LESS THAN BASE LENG.
LENGTH=  50  BASE=  305
E042 LESS THAN BASE LENG.
LENGTH=  200  BASE=  300
*PIECE CHECK*

**AS03210

E042 LESS THAN EASE LENG.
LENGTH=  50  BASE=  305
E042 LESS THAN BASE LENG.
LENGTH=  200  BASE=  300
*PIECE CHECK*

**L001151

E042 LESS THAN BASE LENG.
LENGTH=  100  BASE=  126
*PIECE CHECK*

**FR01012

*PIECE CHECK*
```

## 3.4 Step-4 Installation Drawing

Draw Dimension Line / Piece Code

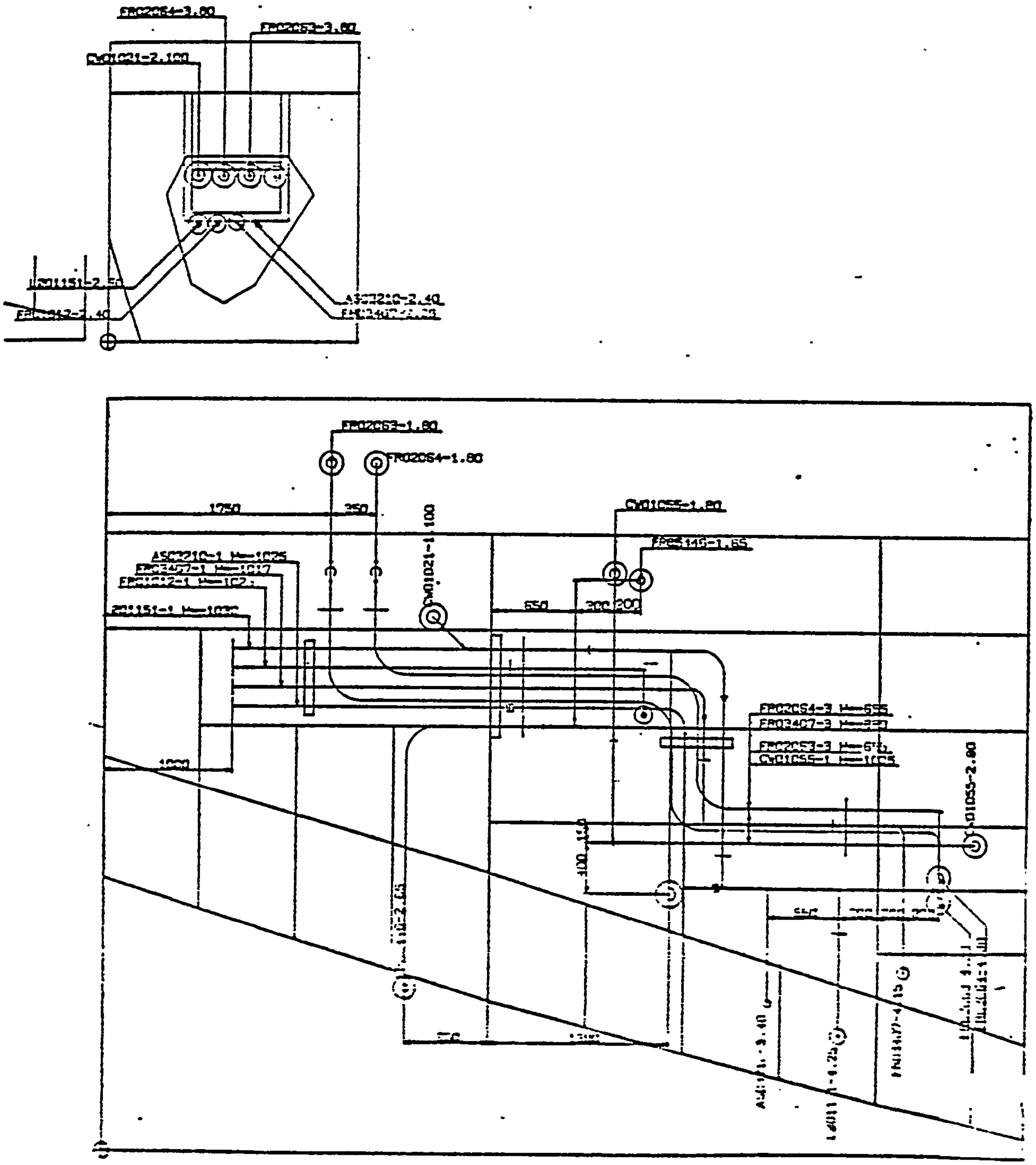
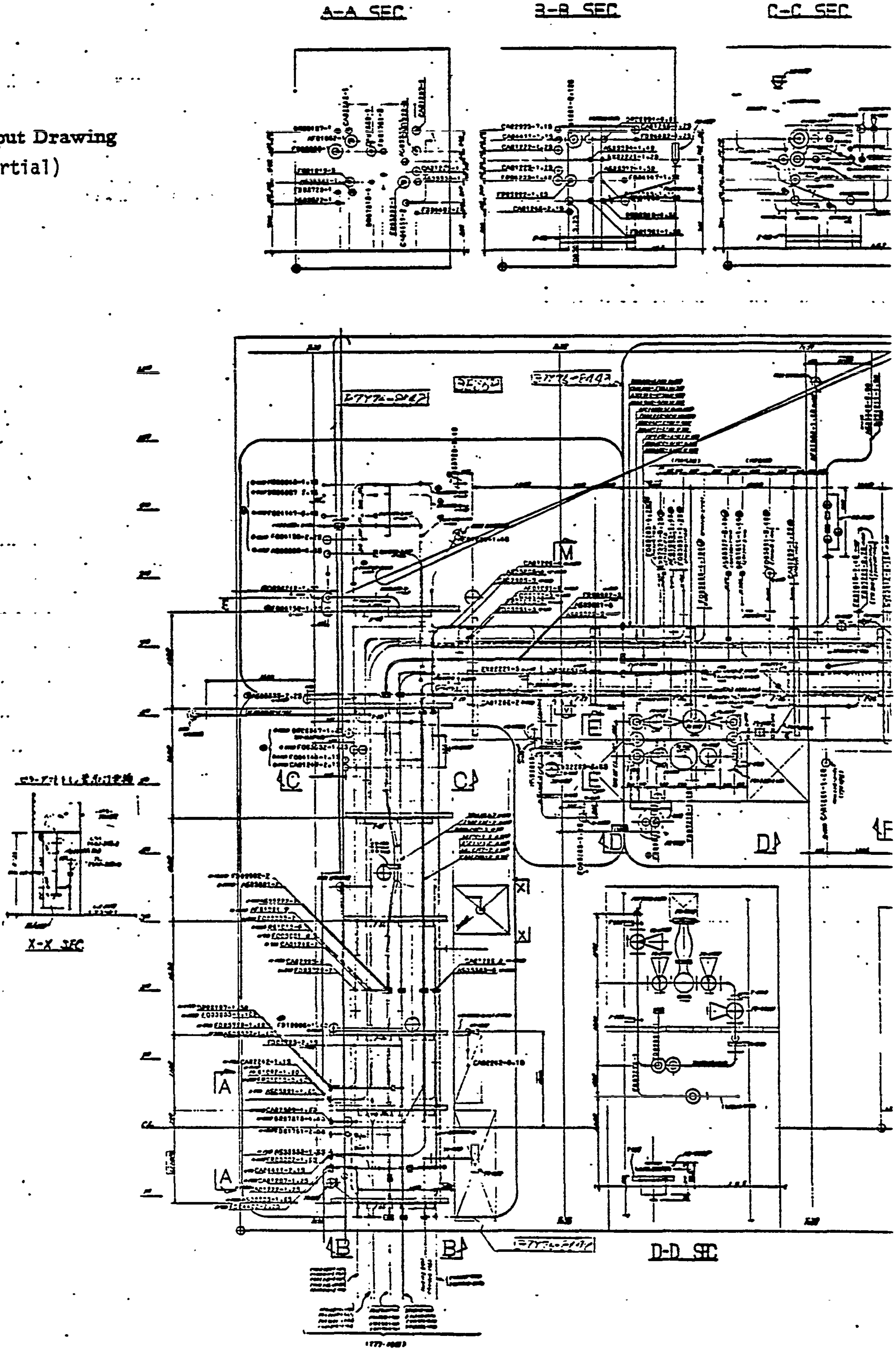



Fig. 3.5

Output Drawing
(Partial)



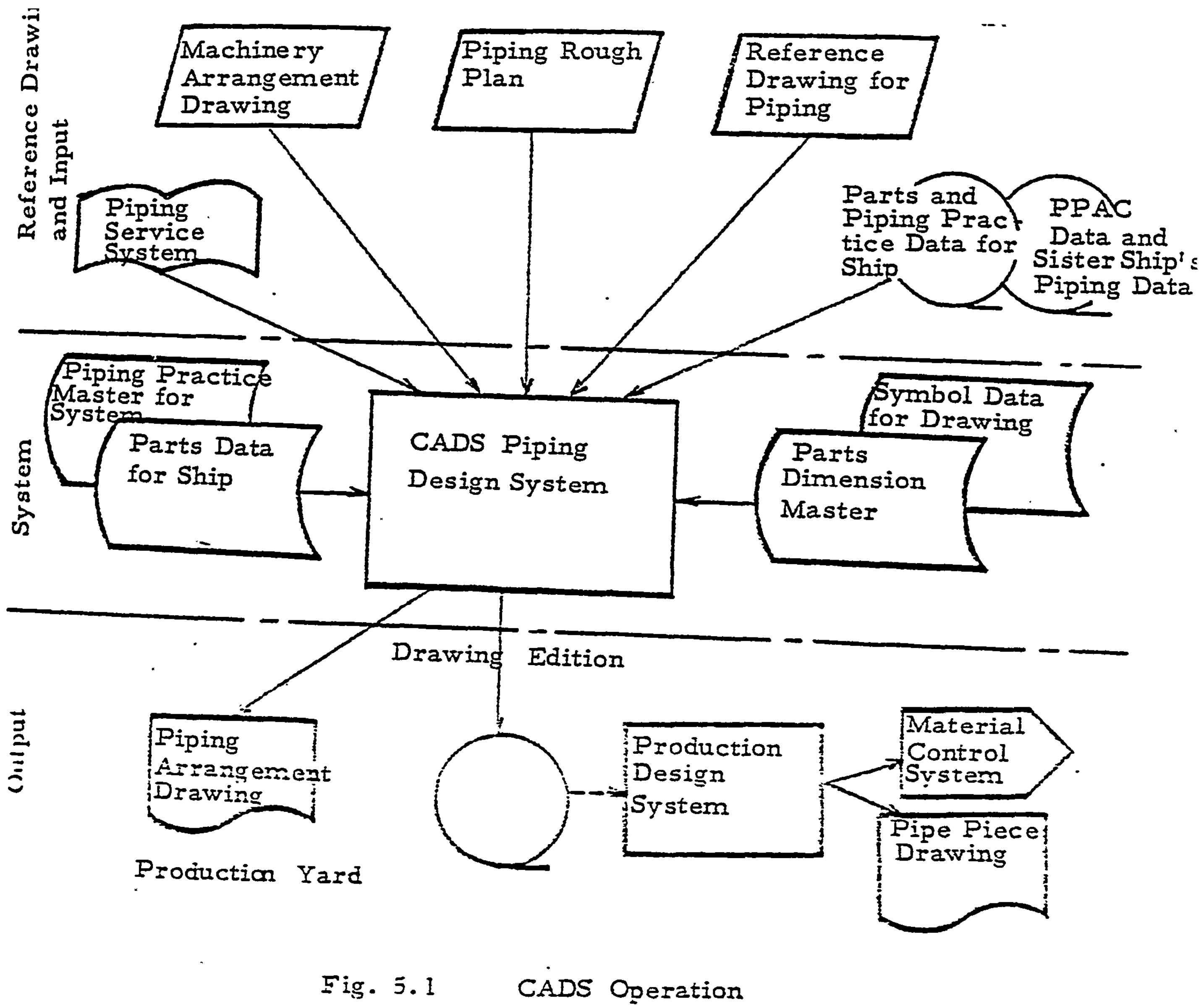



Fig. 5.1 CADS Operation

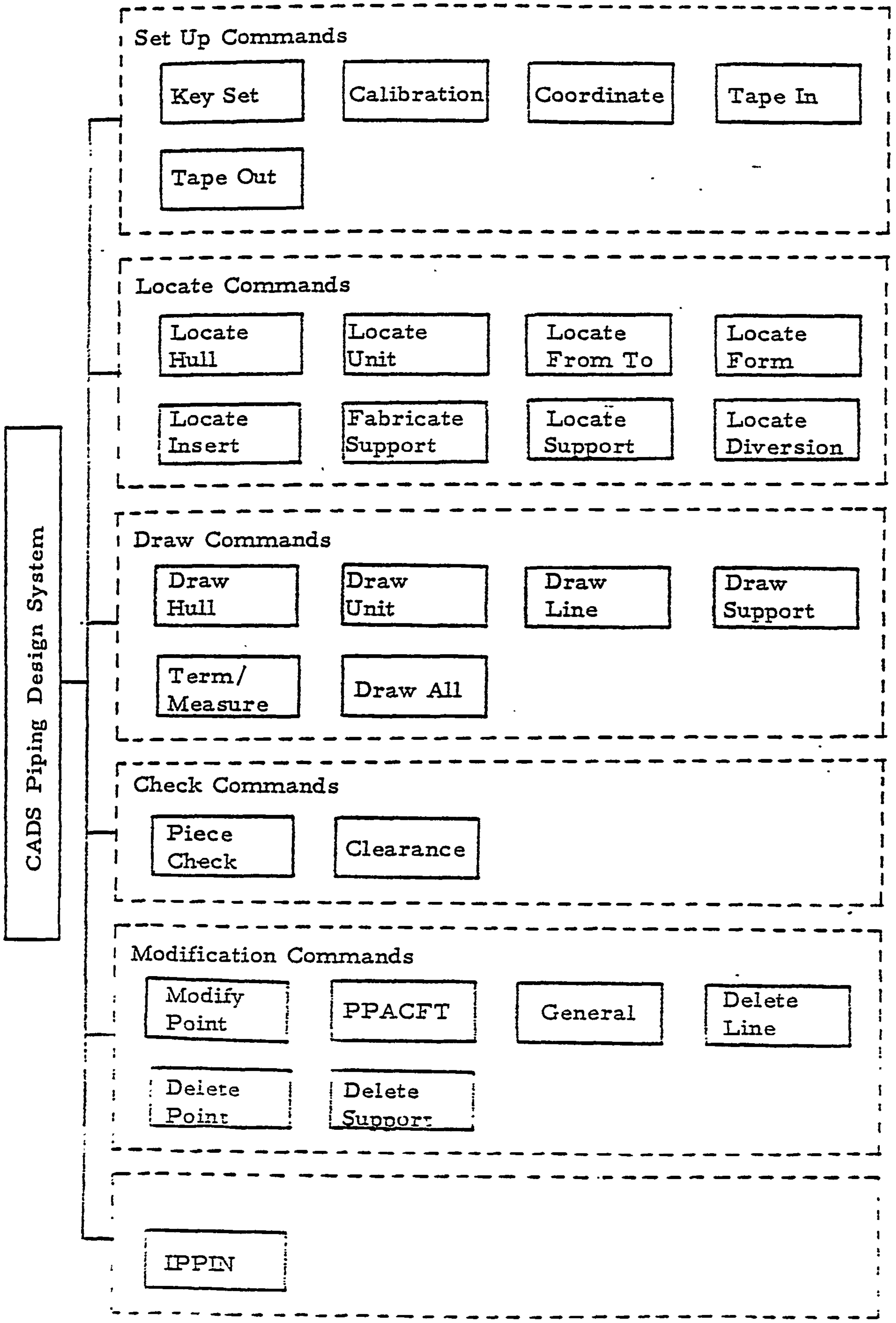

CADS Piping Design System
Set Up Commands
Key Set
Calibration
Coordinate
Tape In
Tape Out
Locate Commands
Locate Hull
Locate Unit
Locate From To
Locate Form
Locate Insert
Fabricate Support
Locate Support
Locate Diversion
Draw Commands
Draw Hull
Draw Unit
Draw Line
Draw Support
Term/ Measure
Draw All
Check Commands
Piece Check
Clearance
Modification Commands
Modify Point
PPACFT
General
Delete Line
Delete Point
Delete Support
IPPIN

Fig. 5.2

## 5.2 Function of Commands

### 5.2.1 Set up Commands Start

1) To set initial values in the system.

2) To set initial values in data files.

3) To input particulars of piping arrangements such as Ship No., Drawing No., Zone, etc.

Coordinate

To define coordinates and their boundaries to be work out on AD table.

Tape In

To read data from the magnet tape and set the data on the file.

Data in the file are pipe data and master data.

Tape Out

To write data on the magnet tape for data transmission to host computer.

Data in the magnet tape are pipe data and master data.

### 5.2.2 Locate Commands

Locate Unit

1) To generate unit data to be stowed in unit standard file.
2) To locate unit data derived from unit standard file.
3) To alter unit data in deviated points from standard arrangement.

Locate From-To

To input data of systems and to locate pipe endpoints in piping arrangement.

Input data:

(1) System names

(2) Pipe end points by coordinates (X. Y. Z.)

(3) Diameter

(4) Pipe piece or fitting name

(5) Others

Locate Form

To locate beding points on the line of the pipe end points through “Locate From-To” command.

Locate Insert

To set parts on the pipe line determined through “Form Command”

Locate Diversion

To set the new pipe line on the designated position by using the piping data defined previously.

Locate Support

1) To set pipe supports on the pipe line

2) To determine the position of U-bolt for pipe on the pipe supports.

Fabricate Support

To design pipe support combining basic pattern of support.

Locate Hull

To define hull structure such as frame, longitudinal and deck as a background drawing.

5.2.3 Draw Commands

Draw Hull

To make a hull structure drawing by data given by “Locate Hull” for checking.

Draw Unit

1) To draw unit data derived from unit standard file.
2) To draw only the end points of the pipe line by data given by “Locate From-To” for checking.

Draw Line

To draw the pipe line by data given by “Locate Form” for checking.

To draw letters and leaders belonging to the pipe.

Draw Support

To draw pipe support by data given by “Plural Support” for checking.

To draw letters and leaders belonging to the pipe support.

Term/Measure

To draw the following marks on the designated positions.

- Pipe Number
- Pipe ***Piece*** Number
- Pipe Fittings Number
- Pipe Support Number
- Pipe Size

To draw letters and leaders on the designated position.
To draw comments on the designated position.

Draw All
To make a final piping arrangement drawing by input data given in previous stage.

5.2.4 Check Commands

Piece Check
To carry out piece dividing of the line and to check the length between two points in the unit of system.
Items to be checked are shown as follows.

- condition of piece fabrication
- condition of Pipe Piece Program
- direct welding
- length of short pipe, etc.

Clearance
To check the clearance between designated two pipes.

5.2.5 Modification Commands

Modify Point
(1) To modify entities of fittings.
(2) To modify all of the coordinates or diameters of the pipe.

PPACFT
(1) To edit pipe data prepared by PPAC.
(2) To separate one pipe lines into plural pipe line

General
To delete and modify co-ordinates.

To delete hull structure, letters, leaders and comments.

Delete Line

to delete pipe data for each system or between designated two points on the piping route.

Delete Point

To delete a designated point of the pipe piece.

Delete Support

To delete pipe support data in the unit of system or piece.

5.2.6 Fabrication and Outfitting Data

IPPIN

To prepare data for pipe fabrication such as:

- Pipe piece Number
- MLF No. and/or MLC No.
- unit sign
- Loose sign, etc.

## APPENDIX H

## IHI REPORT ON COMPUTER-AIDED DESIGN SYSTEM

K2123

TASK 2 ENGINEERING AND DESIGN

SUB-TASK 2.1 COMPUTER-AIDED DESIGN SYSTEMS

1. Examine and Study the SPADES System
2. IHI System
3. Comparison of the Capability between Levingston's SPADES System and IHI System

March, 1979

Prepared by: Masumi Hatake
IHI MARINE TECHNOLOGY, INC.

## 1.0. Examine and Study the SPADES System

The SPADES system of computer -- aided ship design has been examined and studied by IHI to determine if full utilization and benefit is being realized from the use of the system at the Levingston Shipbuilding Company. The study has been proceeded from November, 1978 through February, 1979 at the Engineering Office and the NC Department of Levingston. This report involves "Over View", "SPADES Modules" and "The Usage of the System at Levingston".

## 1.1. Over View

### 1) General

The SPADES system can be seen enough to cover almost over all from the design engineering to NC lofting and preparation for production in its function. Its capability shall be evaluated adequate to support many users which build various shapes and sizes of ships. In fact, it has been used by many shipyards in the U.S.A.

Moreover SPADES has enough space and more applicable field to be developed in the future. Newly developed programs, DEMO and SPAC, will make it possible to expand the users operation.

### 2) The Usage of the SPADES System at Levingston

The Levingston Shipbuilding Company is not using all modules of the SPADES system. Indispensable modules for minimum NC lofting are now in use. From the view . point of usage, SPADES system shall not fully display its worth at Levingston. The main reason shall be in lack of a large drafting machine. FAIRING and ship's hull calculation must be trusted to the Cali and Associates and others. And many difficulties and uneffective matters due to the lack of drafter can be found. If the drafting machine is provided, a useful module of SPADES, DEMO, shall be easily installed to this shipyard. In this concern, more detailed description shall be presented in 1.3.

### 3) Some Problems Pointed Out by IHI

(3-l) The output for making a material cutting list:

## 1.1. Over View (Continued)

The output through the system is good enough for full support of NC burning machine. On the other hand, the output for hand marking and hand cutting shall be rather poor. A material cutting list for flat bars, angles, slabs and face plates shall be obliged to be prepared by hand through the results of parts generation.

(3-2) Stiffeners development on a web plate:

Concerning PARTS GENERATION, a web plate and the stiffeners on it, such as brackets, are separately defined. Most of stiffeners on a web have close relationship with it. If they are defined at a time, the output through PARTS GENERATION shall be automatically provided with the useful data such as:

Precisely marked starting and ending point of stiffeners in taking account of stiffeners plate thickness.

Marking the shifting direction of stiffeners plate thickness.

Drawing of stiffeners identification number on a web plate by drafting machine.

In this concern, more detailed study shall be continued later.

(3-3) Installation of the shipyard's standard data:

Some of the designing standard of a shipyard can be easily installed to the system with a few input. The standard of cutout is a good example. However it

1.1 Over View (Continued)

does not seem to be *easy,* at this moment, to install the standard data in the field of production such as a bevel angle for welding, excess at joints and detailed end shape of stiffeners.

Taking a bevel angle for welding between stiffeners and *a* web plate, as an example, this angle shall be decided by the intersection angle between them. It shall be troublesome work to input the bevel angle by referring the manual of bevel angles as the key data of the intersection angle or referring working drawing. If the process can be treated by the system, it shall be more helpful for the users.

But this problem shall be resolved when the most of shipyards in the U.S.A. establish-their own standard. The urgent theme shall be to set up the scheme of the said standard in Levingston.

(3-4) Problem concerning a curved shell unit:

The output for plate assembly from the PIN/JIG module might be inadequate. Dimensions for checking the shape of a curved shell unit, such as girth length at both end seam and end butt and diagonal length of *a* unit, are necessary as well as positioning data for the corner points of the unit and height dimension. at each pin/jig position.

However this problem has a close relationship with the fabrication method of a curved shell unit. Therefore it shall be prior theme to establish the fabrication method for a curved shell unit from gas cutting, bending, plate assembly and fitting frames and fitting web frames.

In this concern, more detailed description shall be presented in 1.2.

## 1.2. SPADES Modules

The following modules have been studied by IHI:

FAIRING
HULLCAL*
HULLOAD
PARTGEN
NESTING
PLATDV
ROLL SET TEMPLATE*
FRAME BENDING
PIN/JIG*
DEMO*
SPAC*

Study has been extended to the modules which have not been installed to Levingston. (* Marked Module) Because it seemed to be necessary to evaluate the SPADES system correctly.

Any comments from Levingston shall be most appreciated.

FAIRING

The Levingston Shipyard indirectly uses the FAIRING Program, because a large drafting machine to draw the faired frame lines is not provided. The Cali & Associates, Inc. calculates for Levingston and drawings as output and data to be stored on the SPADES Data Base are sent back to Levingston.

Lines fairing by computer has been one of the most basic matters for every shipyard in the world since a computer was first applied to Naval architecture. Because almost all of primary technology necessary for digitizing are involved in lines fairing. Smoothing, curve fitting, interpolation 'is a good example. Without these technology, NC (Numerical Control) and development of pieces of ship's hull, such as a curved shell plate, a curved frame and even an internal structure might not have been performed. Moreover from the view points of manhour saving, keeping high accuracy and scarce skilled loft man, lines fairing shall be a most essential theme.

It seems to be very hard to have a perfect fairing program for every kind of ship's hull. The ship's hull form is usually designed to fulfill the ship's purpose and ship's performance, so that the shape is varied very widely. Initial trim, skeg, bulb, notch, sonor dome and appendage are not *easy* to handle. Therefore, lines fairing program should be provided with the function of how to combine the said complex parts to the ordinary surface.

The FAIRING Program of SPADES system has been. observed to be well-designed. The principles of analysis and processing are very clear to understand for designers and loft men, and very reasonable. For example, curve fitting method of the program is very similar to

FAIRING (Continued)

the one of fairing by hand. The other outstanding function is to recognize the characteristics of curvature and point; such as straight, knuckle, tangency, a large radius curve and a small radius curve.

The Fairing Program has been serving to not only Levingston but also many other shipyards in the U.S.A., which build many kinds of ships. From this fact, the program is to have adequate flexibility to the variation of ship's hull form.

## HULLCAL

The Levingston Shipbuilding Company does not use the HULLCAL program. SHCP (Ship Hull Characteristics Program) developed by the U.S. Navy is now in *use* at Levingston. Therefore, it is not possible to report the usage of the HULLCAL program in practice.

However, a brief comment on the HULLCAL program can be presented through the reference of its user's manual. The following calculations can be performed by the HULLCAL program.

- Curves of Form and Hydrostatics
- Bonjean Curves of Stability
- Floodable Length Curves
- Tank Capacities and Sounding/Ullage Tables
- Prim calculations
- Damage Stability
- Longitudinal Strength
- End Launching Calculations

Tables of the results are printed out. Drawings by the N/C drafting machine of the results can also be generated as an option.

Levingston has a problem to be solved in launching calculation: Side launching is obliged at Levingston, however, there is no suitable calculation computer program.

In addition, it seems to be useful if information and data necessary for ship's operation and test trials before ship's delivery, such as, Turning Test and Crash Stop Astern/Ahead Test, are performed.

HULLOAD

The HULLOAD program is a module to generate descriptions of hull structures and related design data by utilizing the hull definition and frame contours, generated and stored by the FAIRING program or obtained as data in other forms.

These descriptions are permanently stored on the SPADES Data Base, which can be retrieved by other SPADES modules.

The following structures and hull geometry can be generated and stored by the HULLOAD program.

- Additional Frames and Canted Frames at an angle to the centerplane
- Breasthooks
- Decks of any shape, defined by sheer and camber contours
- Deck Longitudinal and Seams
- Shell Longitudinals and Sight Edges
- Longitudinal Bulkheads
- Cut-Out Requirements
- Bulkhead Stiffeners and Seams

The HULLOAD program is provided with sufficient, capability to generate hull structures and hull geometry necessary for succeeding design works. The high availability of the program can be supposed from the feature of generating CANTED FRAMES and BREASTHOOKS which requests an interpolating technique of high grade. Input data of the program is not so much and re-input due to design change is also easily performed.

## PARTGEN (Parts Generation)

PART GENERATION is a program primarily designed to allow the lofting of all flat plate parts needed in the hull of ship. A limited amount of developed parts such as cambered deck can also be generated.

The output of the program consists of one or more of the following:

- Storage of the individual part or burning tape into data base
- Nesting information for use with the nesting program
- Paper tape for the drafting machine
- Calculation list for making a material cutting list by hand

PARTGEN program shall be considered good enough in its function which should satisfy the needs from NC lofting. The adequate function to define element surfaces of parts; such as points, straight lines, circles and curves; and to define contours, holes, cut-outs and stiffener's location are provided. In addition, the function to retrieve the description of ship's hull previously loaded and the function to calculate geometrical matters used for defining parts and for making a material cutting list.

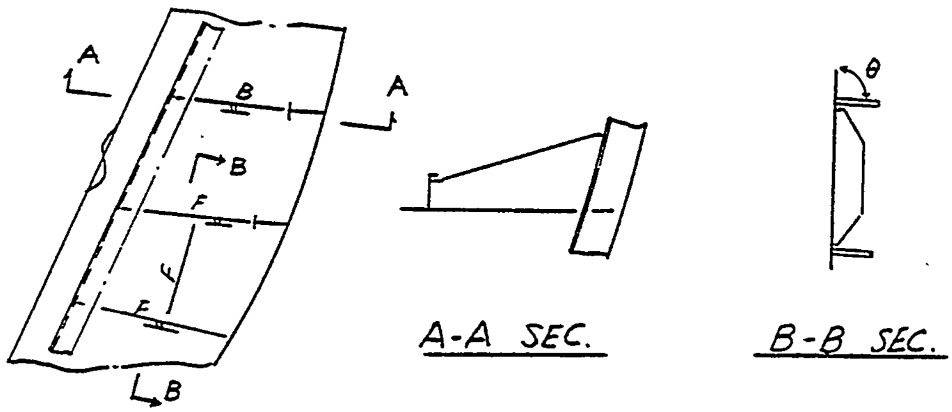
However, the following can be pointed out by IHI for future betterment.

1) Definiation of Stiffeners on a Web:

A web plate and the stiffeners on it such as brackets are separately defined by this program even if most of stiffeners on a web have close relationship with it. The stiffeners also correlate each other.

PARTGEN (Parts Generation) (Continued)

This may be very clear by the following figures:




If they can be described at a time, following merits shall be expected.

- Input for parts generation of stiffeners can be saved.
- Output for all parts of the sub-unit can be generated at a time.
- Marking line for stiffeners can be precisely drawn in taking account of plate thickness.
- The shifting direction of stiffener's plate thickness can be drawn automatically.
- Stiffener's identification number (piece mark) on a web plate can be automatically drawn by a drafter.

2) Output for a Material Cutting List

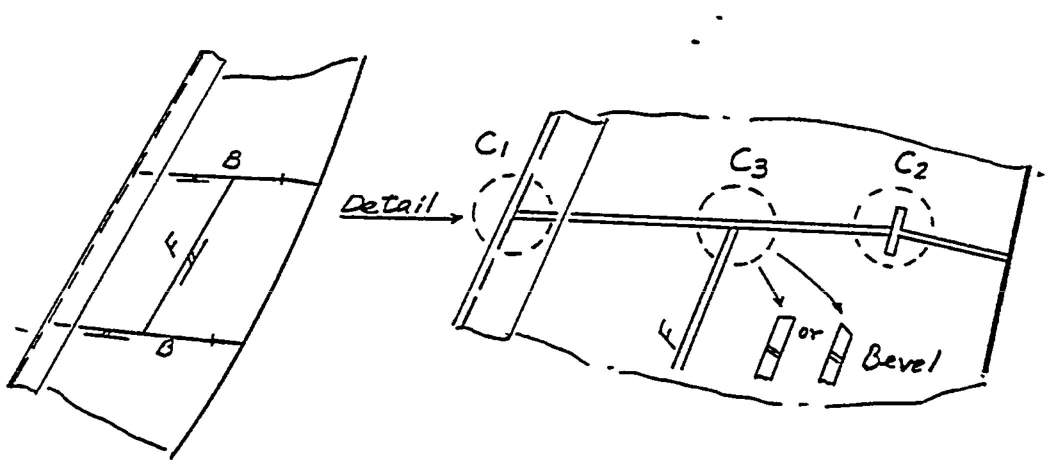
Necessary information and data are generated by PARTGEN and printed out to make a material cutting list for flat bars, T-bars and face plates. Comparing with the function for full support of NC burning machine, this output seems to be rather poor. If some features for automatically drawing a material cutting list are added, the output shall become a finished material cutting list.

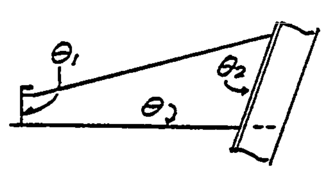
PARTGEN (Parts Generation) (Continued)

3) Installation Shipyard's Standard

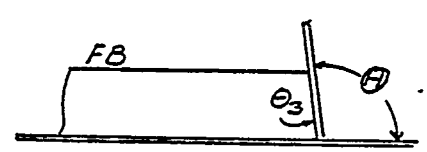
Some of the designing standard, such as shape of bracket, end cut of frame and cutout are easily installed by the system. (HULLOAD and PARTGEN) However, it does not seem to be easy at this moment to install the production standard, such as a bevel angle for welding and excess at joint.

Taking a bevel angle for welding at a bracket on a web, as an example, this angle shall be decided by the intersection angle with the correlating structures. Refer to the following figures.




BKT




FB

PARTGEN (Parts Generation) (Continued)

Bevel angles $\theta$, $\theta_1$, $\theta_2$ and $\theta_3$ shall be decided from $\Theta$ and from the intersection angles at $C_1$, $C_2$ and $C_3$ respectively. Though these intersection angles can be calculated and printed out by PARTGEN, the actual bevel angles ($\theta$, $\theta_1$, $\theta_2$, $\theta_3$) will have to be decided by user. In addition, it seems to be important to remind that the precise length and the precise location of the stiffeners can be finalized through this process.

If these standards or schemes are established and treated by the system, users can be released from this troublesome works.

## NESTING

The NESTING Program defines location (in the plate) and alteration of pieces, center punching, inner hole and outer contour. Finally the program generates a paper tape for a NC burning machine. This program is provided with almost all necessary functions, such as Piercing, Common cut, Automatic center punching sequence and Bridging, except Bevel cutting.

For bevel cutting, a programmer codes in NC tape to stop the machine at both start and end point of a surface with bevel. Then a machine operator sets the bevel angle of the cutting torch by hand. This work seems to be inconvenient for operators because they might have no information on the direction where the machine goes ahead. It shall be recommendable to have automatic cutting of bevel, however, it may be complicated to be provided with the function of automatic bevel cutting which can be of great help for saving time and precise cutting.

In this concern, more detailed description shall be presented in another report "Numerical Control Steel Fabrication".

## PLATDV

The PLATDV program is a module to develop three dimensional surface into flat plate, commonly used for shell plate development, for cold roll process.

The methods used in the program are triangulation and girth length. There can be seen some problems in accuracy at the surface with large curvature as described in the user's manual. Though it is not very clear that the said inaccuracy is caused by the developing method itself or by cold roll process, there may be problems in the both.

Concerning the developing method itself, the following shall be considered to be the cause of inaccuracy:

1) The girth length is calculated from the arc length of the circular arc to be defined with three space points. In case of "S-curved" surface and sparse arrangement of space points, the girth length of the circle shall differ from the true length.

2) Error shall be accumulated during repetition of development from the starting part to the final part of plate by the triangulation method. This tendency shall become conspicuous as the length of plate is longer and as the curvature is larger.

3) Function to correct the error during cold roll process is not provided. Generally the plate is known to be stretched by cold roll. This margin should be considered.

As described at 'FAIRING', SPADES provides a good interpolation algorithm. If this algorithm is fully applied to approximate and interpolate the curved surface, the result shall be much amended.

ROLL SET TEMPLATE (Manufacturing Aids)

For lack of a large drafting machine, the ROLL SET TEMPLATE program is not now in use at Levingston. So that the templates are obliged to be made manually by loft men.

A brief comment on the ROLL SET TEMPLATE program can be presented through hearing from Levingston's personnel who used to utilize the program.

A number of templates at frames including two extremes can be provided by the program. In case that the plate to be bent has a double curvature or a tight curvature lengthwise, other templates at longitudinal frames and/or water lines shall be prepared by hand referring output lists through the other programs of Manufacturing Aids.

It seems to be troublesome a little for loft men to judge the curvature of plate and to handle those programs. It may be more applicable if the ROLL SET TEMPLATE program handle the said conditions by itself.

## FRAME BENDING

The FRAME BENDING Program generates the information required for bending longitudinal and transverse frame and produce templates for the end cuts of the beams. The output can be in one or more of several different forms:

- Full size/reduced scale templates or drawings of the true curvature or the inverse curvature.
- Tabulated offsets of the inverse or true curvature at specified increments along the chord of the beam.
- Full size templates for the end cuts of the beam.

Using these output, the following works can be performed:

- Marking full size templates by hand.
- Preparation for conjunction with a frame bending machine.
- Checking after bending by a previously marked inverse curve.

Concerning this subject, it might be meaningful to note that bending performed by the FRAME BENDING is limited to two-dimensional curvature. On the other hand, IHI system allows to bend three-dimensional curvature (space curvature or twisted curvature). The difference might come from the one of bending practice and design practice between U.S. shipyard and Japanese shipyard.

PINJIG

The PINJIG Program has never been used by Levingston, because assembly on pin/jig has not been applied. Through the study by the users manual, following problems could be found.

Positioning data for the corner points of the unit and height dimension at each pin/jig position shall be fulfilled with output through the PINJIG Program. However, more information shall be required for assembly such as:

- Girth length at both end seams and end butt.
- Diagonal length of a unit to check the shape of a unit.
- Fitting angle of internal structures (such as web frames, girders and longitudinal/transverse frames) to shell plate.

This information may be calculated by the program "Manufacturing Aids". It shall be recommendable that the system is provided with the function to totalize the output from the PINJIG Program and the output of the said additional data which may be calculated by the modules of Manufacturing Aids.

DEMO (Engineering Detailing Module)

1) The Levingston Shipbuilding Company has not yet installed 'DEMO', which was a newly developed module to utilize the time and effort spent during the detail design phase for numerical description of the ship structure. Therefore, it is not possible to report the usage of 'DEMO' in practice.

However, it seems to be necessary to report on the new module DEMO. Because DEMO is one of the representative modules to evaluate the functions of the SPADES system, especially to evaluate its- future development.

A study by the preliminary description of DEMO module has been done and a few comments are presented as below.

2) The characteristics and purpose of the DEMO modules are as follows:

a) Visual checking of the previous loaded data base increases and the data base becomes more comprehensive, verification of loaded data becomes more and more difficult. By checking the data loaded on the data base with drawings performed through this module, the possibility of errors downstream during part generation can be greatly reduced.

b) An efficient tool for detailing:

All through members affecting other surfaces must be handled by 'HULLOAD'. On the other hand, local details will be-defined by 'DEMO'. Details

DEMO (Engineering Detailing Module) (Continued)

are defined as follows:

. Stiffeners:

Symbolic Name
Contour Definition
Shape Code Number
Orientation (near side or far side)

. Seams:

Symbolic Name
Contour Definition
Welding Detail (bevel and gap)
Thickness on both sides

. Holes:

Symbolic Name
Contour Definition
Thickness, Width and Offset of Face Bar

. Brackets:

Symbolic Name
Contour Definition or Standard
Detail Identification
Thickness
Width and Thickness of Flange

. Inner Lines:

Contour Definition
Width and Thickness of Face Bar

C) Saving manhour input for part programming:

Using the function of parts separation of part generation to the detailed designed structures by DEMO, manhour input for part programming will be greatly reduced.

Programming capabilities and language are designed as close to 'PARTGEN' as possible, and all 'PARTGEN' tools, such as Math, Contours, Symbolic Calls, Loops and Reps will be available.

DEMO (Engineering Detailing Module) (Continued)

d) As a result of design work performed by 'DEMO' associated with 'HULLOAD', structural drawings can be completed with the exception of lettering and dimensioning.

3) IHICS (Integrated Hull Information Control System) of IHI involves the close function of 'DEMO' and 'HULLOAD'. There can be found close similarity on the purpose and aim between the SPADES system and IHI system, even if detailed approaching methods are different from each other.

4) Before installation of 'DEMO' for Levingston, some of the preparation should be requested.

a) A large drafting machine should be necessary.

One of the main purposes of 'DEMO' is on verifying drawings. In order to make 'DEMO' useful, a large drafting machine will have to be used.

b) Preparation on Levingston's design standard:

In order to use 'DEMO' in full worth, design standards will have to be reviewed though some of them have been established.

Design standards are as follows:

- Symbolic Name of Stiffeners, Seams, Holes and Brackets.
- Contour (shape) of Stiffeners and Brackets.
- Welding
- End Connections of Stiffeners (lap, snipes, knuckles)
- Drawing standard

These standards should be arranged for easy application to 'DEMO'.

DEMO (Engineering Detailing Module) (Continued)

5) Future scope of 'DEMO':

It seems to be meaningful to try thinking of the future scope of 'DEMO'. As mentioned in 'Over View' of this paper, the SPADES system has enough space to be developed in the future.

'DEMO' and 'SPAC' (Ship Production and Control Module) shall be nucleus for the future development of the SPADES System. From the viewpoint of computer technology, there can be found interesting matters around the said modules. Technology of cathode lay display is one of them.

Quick verification of data on the Data Base, detailing by 'DEMO' and correction can be easily performed by a character display or a graphic display. After checking the data, drawings shall be completed by a large drafting machine. This process shall be of great help for reducing the turnaround time. A sample work flow on this matter is displayed as follows:

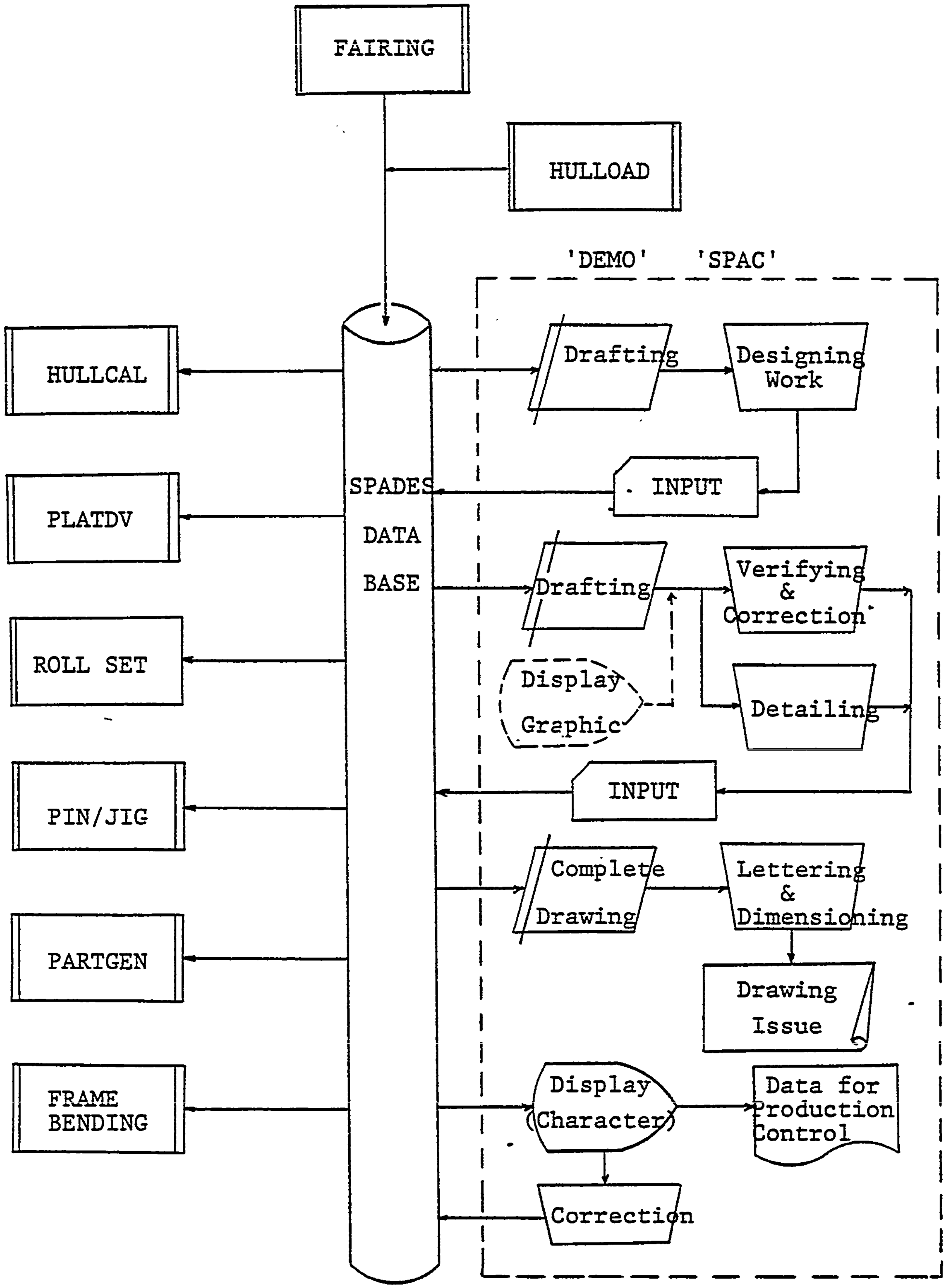
It does not seem difficult to attach these features to the SPADES System. However, the development will have to proceed in taking account of the cost to be required for users.

Though the future scope of 'DEMO' can be expanded to the said advanced computer technology, the recommended future scope at Levingston shall be to install 'DEMO'. associated with a large drafting machine and without the cathode lay tube technology.

DEMO (Engineering Detailing Module) (Continued)

A Sample Work Flow with Advanced 'DEMO' and 'SPAC'

(Future Scope)



SPAC (Ship Production and Control Module)

The Levingston Shipbuilding Company has not yet installed 'SPAC' which *was* a newly developed module to utilize the data needed to generate the required reports for production. Therefore, it is not possible to report the usage of 'SPAC' in practice.

By preliminary description of 'SPAC', the following functions shall be provided to 'SPAC' as listed below.

Unit weight of pieces and weight and centers of gravity of assemblies and sub-assemblies.

Length and nesting within standard lengths of shapes of the various individual shaped pieces.

Cross reference between assemblies due to the nesting into *a* plate of pieces belonging to different assemblies.

Processing time for N/C burning tapes and flame planer sketches.

Bulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.

Revision control is maintained by the system for all the issued reports generated, and many others.

IHI System involves such kinds of modules in use *as:*

Piece list issuing program for sub-assembly, assembly and erection.

Piece mark, number of pieces, weight, shape of piece (including material dimension) are involved.

SPAC (Ship Production and Control Module) (Continued)

Material control program and others.

Through IHI's experience, the function of 'SPAC' as a necessity is easily understood, especially the function of piece list issue required at Levingston. However, these matters shall request for user shipyards to make more clear their method for administration of their organization from engineering through production. Therefore, it might be prior matter to establish clearly their production process and material flow to install 'SPAC'.

## 1.3. The Usage of the SPADES System at Levingston

1) The modules of the SPADES System to be used at Levingston are shown in the following table:

| MODULE \ ITEM | USAGE | REMARKS |
|---|---|---|
| HULLCAL | Unused | SHCP (Ship Hull Characteristics Program) developed by U.S. Navy is now in use. |
| FAIRING | Used Indirectly | For lack of a drafting machine, Cali & Associates Inc. calculates for Levingston. |
| HULLOAD | Used | Checking by a small plotter |
| PARTGEN | Used | Ditto |
| NESTING | Used | Ditto |
| PLATDV | Used | Ditto |
| ROLL SET | Unused | Making templates by loftmen |
| FRAME BENDING | Used Partially | Bending list only to be calculated |
| PINJIG | Unused | Plate assembly on PINJIG is not performed. |
| DEMO | Unused | Not yet installed |
| SPAC | Unused | Not yet installed |

## 1.3. The Usage of the SPADES System at Levingston (Continued)

As shown above, only five modules of the SPADES System are now in use and another one is partially used. As for HULLCAL module and module, concerning fabricating a curved shell unit, there can be seen clear problems as follows. For the others, a totalized study shall be required. In this concern, a detailed study and recommendation shall be presented later.

## 1.3. The Usage of the SPADES System at Levingston (Continued)

2) For HULLCAL module, following problems have been pointed out by the user engineer at Levingston. Therefore SHCP (Ship Hull Characteristics Program) developed by U.S. Navy is now in use instead of 'HULLCAL' of SPADES.

(2-l) Problems pointed out at Levingston:

. The program of Damage Stability Calculations cannot be sunk below the Margin Line in damage at 0 heel. The Margin Line cannot be made above the uppermost deck in the present version at Levingston.

. Documentation does not always agree with the User's Manual.

(2-2) Additional problem at Levingston:

. Side Launching is obliged at Levingston, however, there is no suitable launching calculation program neither in SPADES nor SHCP.

(2-3) Information and data necessary for ship's operation and test trials before ship's delivery:

. It seems to be useful if the said information, such as Turning Test and Crash Stop Astern/Ahead Test are performed by

3) PLATDV, ROLL SET, FRAME BENDING, PINJIG:

These are the modules for fabricating a curved shell unit. PLATDV is only in full use and FRAME BENDING is partially used. The others are not in use. The usage of these modules seems to be unbalanced. Lack of a large drafting machine shall be the cause. However, it might be possible to make a template for bending a curved plate or a curved frame through the output of 'ROLL SET' or 'FRAME BENDING'.

PLATDV, ROLL SET, FRAME BENDING, PINJIG (Continued)

As far 'PINJIG', fabrication method for a curved shell unit is the primary theme. Levingston has not decided to adopt the assembling method of 'PINJIG'. One of the biggest differences in constructing technology between Levingston and IHI lies in this method. This theme shall be studied through the Technical Transfer Program.

4) Total View on the Problems Facing at Present and in Future

The urgent themes to be studied at Levingston are as follows:

- Working drawings to be issued as fast as possible with a suitable advance for study on fabrication method by production people.
- Easy and quick follow-up to design change caused by the Owner's opinion, claims from the classification society and convenience of production method.
- Manpower saving both at the Engineering office and Lofting.
- Error caused by mis-input to she SPADES modules to be minimized for the smooth operation of the system and for preventing the production process from confusion due to errors.
- Consideration for scarcity of skilled loftmen.

The following are supposed to be concrete problems and difficulties to realize the said themes.

4) Total view on the problems facing at present and in future. (Continued)

(4-l) LINES FAIRING must be trusted in Cali & Associates, INC., so that TAT (Turn Around Time) of it gets longer and money is lost. FAIRING IS the most fundamental for quick start of every designing work. If the work can be performed by Levingston itself, the faired lines shall be brought more quickly in low cost.

(4-2) Visual checking is not so easy. Results of 'HULLOAD', 'PARTGEN' and 'NESTING' are obliged to be checked with small scaled drawings. This might cause some errors and inaccuracy.

(4-3) Duplicated works can be seen between the Engineering office and Mold Lofting.

Most of manhours are spent for making working drawings at the hull section of the Engineering office. The working drawing might be beautiful enough to express the ship's structure. The most detailed dimensions and all necessary information are involved in the drawings. Piece mark system, plate thickness shifting direction of stiffeners, cutouts, end cut of stiffeners and welding information are described. They are drawn by hand, as if drawn by a drafting machine.

On the other hand, input for 'HULLOAD' is simultaneously prepared at the Engineering office for the succeeding jobs. Then the input will have to be verified by drawing with a small plotter for only visual checking.

4) Total view on the problems facing at present and in future. (Continued)

If the input for 'HULLOAD' precedes and drawings are drawn by a drafting machine with a suitable scale., the drawings can be utilized as the base drawings from which more detailed design can be performed as well as checking drawing for input.

In addition, in N/C lofting at present, lettering and dimensioning will have to be obliged to be performed by hand referring the working drawings. This duplicated work is being performed in a small scaled drawing.

(4-4) Manual lofting in full scale still remains at pretty range.

In order to make a template for bending, a full scaled line is being drawn. This work can be performed by the computer system and by the sealed' lines. From the viewpoint of scarcity of skilled loftsmen, this kind of work might be replaced by the computer system as much as possible.

5) Some recommendations from IHI for the better usage of the SPADES system at Levingston:

Through IHI's study on the SPADES system used at Levingston, concrete problems described in the previous paragraph remain. What is needed at Levingston at this moment to solve the said problems shall be to make full use of the SPADES system. For each module of the SPADES system, IHI's recommendations have already been described in 1.2. The following are the additional recommendations from IHI.

5) Some recommendations from IHI for the better usage of the SPADES system at Levingston (Continued)

(5-l) To install a N/C Directed Drafting Machine for the Engineering and the Loft:

A small plotter has been provided for the loft. However, it cannot satisfy the need from Engineering and Lofting as aforementioned at 1.3-4. By utilizing a N/C Drafting machine, these problems can be fairly proved.

The requested drafting machine shall have a 70" x 150' effective drafting area and its cost is estimated to be $100,000-$150,000. Installation of a N/C Drafting machine makes it easy to install 'DEMO', which shall contribute to the betterment described already, such as:

- Fast issue of working drawing
- Easy and quick follow-up to design change
- Exclusion of duplicated works
- Manpower saving

(5-2) To confirm data flow from the Engineering office, including lofting through production:

In order to realize the said urgent theme, the actual data flow extended from Engineering Office through Production field, which is now getting clear, shall be expected to be confirmed. This confirmation and selection of IHI's recommendation described in this paper (1.2, 1.3) are requested to be proceeded simultaneously.

## 2.0. IHI System

The Computer-Aided Hull Design System of IHI covers almost over all of hull design field from the initial design, detailed design through production engineering.

IHI system consists of six (6) independent main systems, which support their particular functions. Some of them are designed to communicate with the other systems through their data base to keep a coincidence of common data between them and to save input. Main systems are as follows:

ZPLATE, ZVIBRA
- Structural Analysis

SPECS
- Ship's Hull Calculation
- Operational Information Calculation

FAIRING
- Lines Fairing

SHELL
- Shell Plate Development
- Template for Bending
- Assembly Unit Marking on PIN/JIG
- Supporting Jig Height Dimension

LODACS
- Longitudinal/Transverse Frame Development
- Template for Bending

IHICS
- Ship's Hull Description
- Section Design
- Parts Generation
- NC Lofting (NC Drawing, NC Burning Machine)
- Parts List Issue
- Data Communication by Display Terminal

## 2.0 IHI System (Continued)

Since many of documents concerning this subject have been already submitted to Levingston, only special characteristics of the said systems shall be presented here. The following are the documents to have been submitted.

(Through our Memo Ref. No. FPC-073 dated February 23, 1979)

1. Brief Explanation of IHICS
2. IHICS - Actual Input/Output Examples
3. Summary of IHI SHELL
4. LODACS - Ship Frame Data Processing System
5. SPECS - Ship's Preliminary and Exact Calculation System
6. SPECS - Actual Output Example

(Through our Memo Ref. No, FPC-046 dated January 18, 1979)

7. The User's Manual 'Z-Plate' Output Sample.

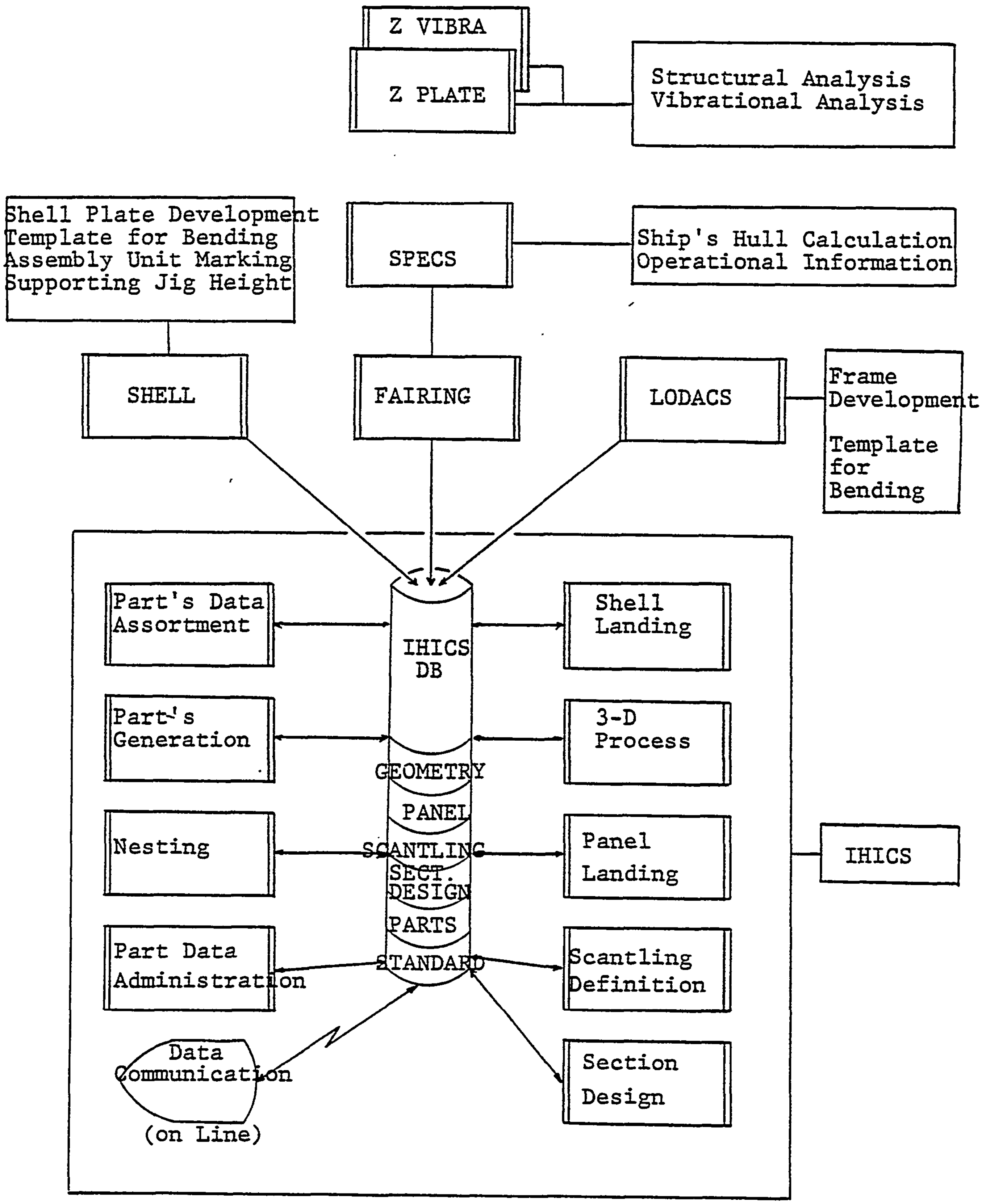
(Through our Memo Ref. No. FPC-029 dated December 20, 1978)

8. General Purpose Program of Plane Stress Analysis by Finite Element Method and Its Application (ZPLATE)
9. Matrix Method of Vibration Analysis of Framed Structure and Its Application

Relationship between the said systems and functions is presented in the following figure.

*IHI MARINE TECHNOLOGY. INC.*

IHI Computer-aided Hull Design System



## 2.1 Characteristics of Each System of IHI

Only special characteristics are described here. Other details are presented in the aforementioned documents. It is coherent in all systems that plenty of drawings can be generated through the systems and that designing know-how through IHI's long experience is concentrated in the systems.

## 2.1 Characteristics of Each System of IHI (Continued)

### ZPLATE, ZVIBRA

ZPLATE is a program for analysis of elastic plate structures under plane stress conditions, and especially a program for three dimensional structure constructed with plates or orthotropic plates will be distinctively useful for analysis of ship hull structure. There exists many good programs covering this field in the world. However, labor to make input data for the given problem is generally too large to use in practice.

ZPLATE solved this problem by adopting a substructure method with the function of automatic mesh generation and with periodic identical pattern. In addition, this program includes also a check device of input data and adjustment of calculated results by using a high speed plotter and a graphic display.

ZVIBPA has been prepared for analysis of vibrational responses in elastic range of three-dimensional framed structures under sinusoidal forced vibration. Because the effects of shear rigidity and rotatory inertia are taken into consideration, this method is particularly effective in the analysis of structures such as the ship hull structures where the effects of those factors cannot be ignored. For vibrational analysis method of framed structures, a method in general use obtains natural frequencies in free vibration by replacing the structure to be analyzed with a structure made up of a multiple mass and spring system. However, in framed structures where shearing deformation and rotatory inertia are taken into consideration, it is extremely difficult to obtain natural values by the use of the above method;

In ZVIBRA, an assumption of the framed structures to be a conglomerate of beams, which have infinite degree of freedom, has been taken and then their stiffeness matrices were obtained using such matrices, their vibrational responses were calculated, and as a result their vibrational modes and amplitudes were obtained.

## 2.1 Characteristics of Each System of IHI (Continued)

### SPECS

SPECS has been applied to detailed design in ship's hull preliminary calculation on Hull Form and its capacity. In addition, necessary information and data at ship's operation and at test trials before its delivery are also calculated. Almost all of the sub-programs of the system generate drawings and curves as well as tabular prints. The actual output examples can be referred to in "Actual Output Example of Ship's Preliminary and Exact Calculation System."

2.1 Characteristics of Each System of IHI (Continued)

FAIRING

IHI FAIRING program performs Lines Fairing by adopting a newly developed interpolating method called 'N-Curve'. 'N-Curve', of which term stands on 'Natural Curve', can express straight line, true circle (arc) and a compound straight line with a knuckle point as well as 'natural curve'.

2.1 Characteristics of Each System of IHI (Continued)

IHICS (Integrated Hull Information Control System)

IHICS is a series of program packages associated with the Data Base. IHICS serves for mainly describing ship's hull structure, section design, parts generation, NC lofting, NC burning machine and parts list issue. The special characteristics are as follows:

1) To be based on Data Base concept:

By excluding duplicate data, incoincidence of data is prevented and the space of the memory on Disk is much saved.

For easy maintenance of the systems and data, programs and data are independent from each other.

IMS (Information Management System) of IBM, Inc. has been adopted.

2) To generate sectional drawings at any location and at any phase of designing.

3) To generate a part program by the system itself (as well as manual coding).

4) To generate parts list for any stage of production (fabrication, sub-assembly, assembly and erection) at an early time.

5)- Parts generation with full information necessary for production (fitting angle, plate thickness shifting direction, bevel angle, piece mark and additional material).

6) Automatical reference of design standard and production standard:

Shape standard - cut out, scallop, bracket, stiffener end cut.

. Standard how to select/apply standards.

. Bevel and gap for welding.

IHICS (Integrated Hull Information Control System) (Cont.)

7) Register and revise of standard data.

8) Material cutting drawings (not lists) with full information necessary for marking.

9) Detailed working drawings for sub-assembly and assembly.

10) Consideration on design change (Refer to the attached paper).

11) Online capability -

Many online terminals are supported under the control of IMS/DB.DC.

12) Connection to Graphic Display.

Listed above are only a summary of the characteristics of IHICS. The more detailed description and actual output examples are presented in the submitted documents.

2.1 Characteristics of Each System of IHI (Continued)

SHELL

The SHELL system constitutes an integrated and computerized data processing system which provides various highly accurated information pertaining to all the processes in production of a curved shell unit. The SHELL system covers shell plate development, making template for bending, unit marking on supporting jigs and jig height calculation. In addition, these calculations are performed under the common base which user planners can input the most suitable condition from the viewpoint of accuracy and workability in the production process. The standardization of production technologies and analysis of application know-how in the SHELL system has been established by mobilizing of the engineering power in IHI's five shipyards.

Special Characteristics of SHELL:

1) Shell system is a composite system for the geometrical calculation and data calculation and a data processing system relevant to the production of a curved shell unit.

2) Shell system displays a far higher level on accuracy as compared with the conventional system. The new ideas and method to be adopted for this matter are as follows:

- In order to make calculating algorithm simple as well as in order to keep the high accuracy of the output, the lines are drawn by the concurrence of points approximated by a certain supplementary straight lines.
- The optional cut-plane method is fully adopted. This is a method to develop a curved shell plate in the view that the characteristics of its curvature are displayed best.
- The desired plate is cut out of a larger expanded plan including the surrounding area of the plate.
- In order to ensure the accuracy at plate bending time, the templates are set up at the right angle against the mean level of the curved plate.

(Refer to Fig. 1 - Fig. 3 in the 'SHELL Manual')

3) A remarkable improvement on workability and accuracy in the assembly stage can be expected. Because the various working

SHELL (Continued)

practice in the shop is taken into consideration from the first step of the system execution.

- In order to keep the accuracy of angles between adjoining seam and butt at plate assembly, the intersection of datum planes in the supporting jig lines and shell plate are marked on each plate. In addition, the datum plane are orthogonal to the platform surface.
- Instructions can be given in connection with the position for setting plate, postion of stopper and the height of supporting jigs.
- The dimensions of unit, diagonal dimensions and the rate of curvature on seams and butts are calculated and displayed for checking at plate assembly time.
- The availability of automatic welding on the unit can be checked.
- Single panel assembly can be also available.

  (Refer to Fig. 4 - Fig. 5 in the 'SHELL Manual'),

4) Maintainability of data and system.

5) Easy recording of feed-back data.

More detailed description is presented in the submitted document.

## 2.1 Characteristics of Each System of IHI (Continued)

### LODACS (A Ship Frame Data Processing System)

The LODACS system covers frame development, frame bending and marking-cutting by hand or by NC burning machine. The LODACS system generates precise shape at both end of frame, inverse curve for bending, location of drain holes and template for bending. These data are drawn by a drafting machine, a plotter and dotto printer as well as printed out.

The LODACS supports three-dimensional bending as well as two-dimensional bending. The need of this function comes from fabricating method on bending.

More detailed description is presented in the submitted document.

ATTACHMENT

## 1. CONSIDERATIONS ON DESIGN CHANGE IN HULL PART

(IHICS: Integrated Hull Information Control System:)
Ref. FPC-073 dated February 23, 1979

Some considerations on design change are involved in the system design strategy of IHICS system which was developed by IHI to perform hull design. The system has been utilizing full in worth.

Design change is considered to be caused mainly by the Owner's opinion and claims from the classification societies. It is very important to remember that designing work for detailing has not been allowed to keep until approval by the said agency is given to the prepared drawings. Therefore, the influences of design change have to be minimized on the designing procedure.

Another consideration to be taken in IHICS is flexibility to the design change due to the change of production method such as welding.

From the viewpoint of computer software, flexibility to this kind of change is fundamentally the same as design change occurring during the period of the actual ship's design.

Some actual examples of the subject to be taken in IHICS are as follows:

1) Relative expression on hull structure by defining language called 'LINE'. 'LINE' is designed to describe objective figures in relative expression as far as possible so as to minimize corrections caused by alteration of design.

   This concept is coherent in all sub-systems.

   (Refer *to* "3) An example of 'LINE' description")

   a) These descriptions will not have to be changed, 'even if the data on longitudinals such as offsets, material dimension and cutout are changed.

ATTACHMENT

These descriptions are executed by the system on both phase of designing and part generation.

b) Generation of physical data of every part can be postponed up to the execution of parts generation.

The shape of the cutout at every longitudinal frame shall be generated after all inputs are given to the system.

2) Independence of design standard data from the computer program.

Design standard data can be registered on the standard data base on the responsibility of designers. Registration and updating can be easily performed by the system.

The following are involved in the standard data base:

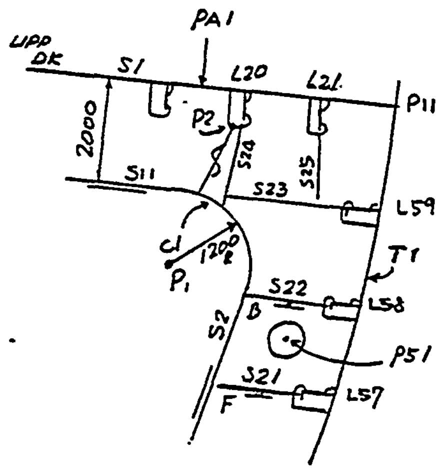
. Shape standard: Cutout, Hole opening, Scallops, Bracket, End shape of stiffeners

. Standard how to select/apply stands

. Fabrication standard: Excess, bevels and gaps

## 3. An example of 'LINE' descriptions

(An example for corner part of transv. section)




Geometric Definition

```
T      F60
     Tl=F60----GEOMETRY DB REFERENCE
     PAl=PA-UD,ML--- PANEL DB REFERENCE
     P11=oUT(sL,UD,1) ---DESIGN DB REFERENCE
     Sl=PAl,Pll
     Sll=PR-SL,L=2000,D
     LONG=SL,L40,L59    GEOMETRY, SCANTLING
     LONG=UD,L20,L21    DB REFERENCE

     Cl=TD-Sll,Tl,-S2
     Pl=CP-Cl
     P2=SLOT-PC2,UD-L20
     S5=PT-P2,PT-Pl
     P3=INT(S5-Cl),U
     P4=ON-Cl,FROM-P3,GL=l5O,D
     P5=UD-L20,TOP
     Al=P100,Sll,Cl,S2, -------------------- COMPLEX SURFACE
     S24=PT-P4,PT-P5,SCS=UD-L2O,ECS=Al
     S21=SL-L57,      SCS=SL-L57,ECS=Al
     S25=UD-L21;      SCS=UD-L21;ECS=S23

C    -----,Tl,MSL(SL,L40,L59),Tl,MSC(lOO),PAl,              CONTOURING
           MSL(UD,L21,L21),PA1,MBS(S5,UD,L2O,P3,21),C1      DEFINITION
     ---- &

H    MH(l,P51,150)                                   ----   OPENING
                                                            DEFINITION

X    S21=F,FIT=A,PD=D,MRK=U,TYP=FClSl,NAM=Fl5
X    S22=B,FIT=A,PD=D,MRK=U,TYP=BClSlSl,NAM=Bl6        PARTS EXPANSION
     -----                                              (STIFFENER)

                                                   END OF PART PROGRAM
```

## 3.0 Comparison of the Capability Between Levingston's SPADES System and the IHI System

Comparison of the capability between Levingston's SPADES system and the IHI system is briefly presented in this paragraph, since deep study and detailed description has been reported in preceding paragraphs of this paper.

In addition, assessment of the interface problems and the adaptability of the IHI system software to the SPADES system is briefly tried for reference.

## 3.1 Comparison of the system component between the two (2) systems.

The following is a component figure of the both systems.
The underlined is not used by Levingston.

| APPLICATION | SPADES | IHI SYSTEM |
|---|---|---|
| Structural Analysis | Unknown | Z-PLATE |
| Vibrational Analysis | SPADES Unknown | Z-VIBRA |
| Ship's Hull Calculation | HULLCAL* (Unused) | DB SPECS |
| Ship's Operational Information | Unknown | SPECS |
| Fairing | FAIRING | DB FAIRLAND IHICS |
| Ship's Hull Description | HULLOAD | Basic Data Creation Subsystem |
| Section Design | DEMO* (Unused) DB | Section Design Subsystem |
| Part Generation | PARTGEN | DB LINE System |
| Nesting | NESTING | Nesting Program |
| Part's Data Assortment | SPAC* (Unused) | Production Engineering Subsystem |
| SHELL<br>Plate Development | PLATDV | DB SHELL |
| Bending Template | Unused ROLL SET* | |
| Jig Height | PIN/JIG* | |
| Unit Marking | Manufacturing Aid | |
| Frame<br>Frame Development | FRAME BENDING (2-Dimensional) | DB LODACS (3-Dimensional) |

3.1. Comparison of the System Component between the Two (2) Systems (Continued)

As shown in the aforementioned component figure of the SPADES system and IHI system, full configuration of the SPADES system covers much the same area as IHI system, except structural analysis and vibrational analysis through SPADES now in use at Levingston, is a part.

In conclusion, capability of SPADES is considered to be almost equal to IHI system. If the betterment for the problems described in 1.1-3) and 1.2 is taken into consideration, and if recommendations by IHI presented in 1.3-5) is studied, the SPADES system shall become full in worth.

## 3.2. Adaptability of the IHI System Software to the SPADES System

A short study on adaptability of the IHI system software to the SFADES system has been done for reference.

1) As far as the computer hardware configuration, there is no special problem for the subject, because the IHI system can be operated on IBM System/370 or IBM 3031 processor.

2) As far as the computer software configuration, there is no special problem for the subject except IHICS. IHICS requests to install the IMS of IBM Inc. (Information Management System)

3) ZPLATE, ZVIBRA, SPECS

There is no problem to adapt to the SPADES system. These have (their own data file and do not request any interface.

4) SHELL, LODACS

This system might request some interface for their data base unless a new data handler from the SPADES Data Base is attached to these systems.

5) FAIRING

This system might request some post-processor form its data file to the SPADES Data Base unless the results are re-input to the SPADES Data Base from the offset book as the output.

6) IHICS

It shall not be recommendable to adapt to the SPADES system, because almost all the modules were coded by IBM PL/1 based on IMS and too big to adapt.

However, algorithm of the system and design philosophy shall be considered to be convenient for reference.

Epilog:

This report *was* made by IHI through the investigation and the discussion with Levingston's personnel. IHI hopes that Levingston continues a study on the subject matter for the future betterment along the recommendations from IHI described in this paper.

# APPENDIX I

## IHI REPORT ON NUMERICAL CONTROL STEEL FABRICATION

K2123

TASK 2 ENGINEERING AND DESIGN

SUB-TASK 2.2 NUMERICAL CONTROL STEEL FABRICATION

March, 1979

- Prepared by: IHI MARINE TECHNOLOGY, INC.

M. HATAKE

# NUMERICAL CONTROL STEEL FABRICATION

The N/C system now in use at Levingston for steel fabrication has been studied by IHI in order to quantify its utilization as compared to its potential capabilities. The study has been in process from November, 1979 through March, 1979, as a part of the extended computer-aided hull design system.

In this paper, a brief description on the usage of the N/C system at Levingston shall be presented since the more detailed description on the function of the system itself can be found in the attached paper. Then a brief study on the characteristics of the usage of the N/C system at Levingston shall be described comparing with the IHI system. Finally, some recommendations from IHI shall be presented,

Attached Papers:

1 . Specification summary for N/C 3000 and N/C 3300 SERIES FUME CUTTERS by C-R-O Engineering Co., Inc.

   Detailed functions of the same machine as Levingston's are described.

2. IHI High-speed N/C Marking. System,-

   This machine was developed by IHI to perform high-speed (about 60' per minute) line marking.

3. IHI Multi-torch N/C Cutting Machine.

   This machine was developed by IHI to perform gas cutting by three torches simultaneously and to perform line marking by two torches simultaneously. This machine was provided with

Attached Papers: (continued)

mini-computer in order to perform checking the interference of each torch, speed control, co-ordinate transformation and many others.

## 1.0 The Usage of the N/C System at Levingston

C-R-O Double Model N/C 3000 flame cutter is now in use at Levingston. It is controlled by Kongsberg CNC 500 with the DNC (Direct Numerical Control) software. The machine is provided with almost all necessary functions to perform the N/C steel fabrication at Levingston such as:

Two sets of the master torch associated with two slave torches for each master torch.

Bevel torch for bevel cutting of (K, V, Y, X).

Center-punched marking equipment.

Automatic pierce rate control.

Automatic start-cut control.

Rotating triple-torch suspension.

Height sensing control.

Water spray system for preventing heat torsion.

Torch ignitor.
Others

The machine has been utilized to fabricate almost all hull pieces, which are cut out of raw plates, except square-shaped small pieces to be fabricated by shearing. After its installation at Levingston in April, 1975, this. machine has covered Levingston's needs with its capability since the work volume of steel fabrication at Levingston was not too extensive. (The past record was 500-metric tons per month.)

1.0 The Usage of the N/C System at Levingston (continued)

However, since it is estimated that the work volume of Levingston's steel fabrication shall be increased to 1500-metric tons per month through the construction of the bulkers, the work load of the N/C machine is expected to become extremely heavy to fabricate the pieces aforementioned. Therefore, some considerations such as; leveling of the work load, rearrangement of supporting area of objective pieces and installation of an additional machine, shall be requested at this moment. In addition, an alternate method of N/C burning machine to compensate the work load in the time of "machine-down" and "repairing" shall be recommended to be studied. In respect to this concern, a little deeper consideration-shall be presented later.

## 2.0 Characteristics of the Usage of the N/C System at Levingston

In this chapter, a brief study on the characteristics of the usage of the N/C system at Levingston shall be described comparing the Levingston system with the IHI system.

## 2.1 Objective Hull Pieces for the N/C Machine

A comparison of the subject title between Levingston and IHI-AIOI Shipyard which constructed the "Future-32" bulkers can be seen in Table 1. The Levingston N/C machine has been utilized to fabricate most of the hull pieces. On the other hand, a quarter of all plates of a "Future-32" was fabricated by the N/C machine in IHI-AI0I Shipyard. In regard to this concern, more detailed descriptions will follow as shown below:

1) Difference of the work volume between Levingston and IHI-AI0I Shipyard.

The past record of steel fabrication at Levingston equipped with one (1) N/C machine was 500-M.T. (metric tons) per month. IHI-AI0I Shipyard equipped with three (3) machines keeps 6000 - 8000 M.T. per month.

2) Difference of the philosophy on steel fabrication.

(2-l) Levingston stands on the viewpoint that N/C burning is the best way from its high precision and from its capability of burning (2) to (3) plates at a time.

(2-2) IHI stands on the following viewpoint:
Though a N/C burning machine is best for high precision and it has a capability of burning (2) to (3) plates at a time, preparatory work for this such as, nesting operation by this system takes man-hours; nesting of twenty (20)

2.1 Objective Hull Pieces for the N/C Machine (continued)

pieces into a raw plate shall take 1.5 - 2 hours, for example: In addition, the layout for a N/C machine needs a Wide space in the shop, Therefore, the use of the N/C burning machine had best be limited to the pieces requiring high precision and the repetitively cut plate from the same N/C tape. In fact, IHI's N/C machines are being utilized for the main structures at cargo hold such as, web plates, floor plates and girders and for the curved shell plates.

2.3 Plate Assembly

For a flat plate unit such as main deck, both Levingston and IHI adopt the preceding plate-assembling method. However, the sequence of it is much different from each other.

At Levingston, marking on each plate is completed by a N/C machine before layout of plates and welding, On the contrary, at IHI each plate is neatly cut by a flame planer and welding of plates follows, Finally, marking on a unit (not plate) is performed before putting the internal structure such as sub-assembled webs on it.

3) Difference of Mold Lofting and Marking Equipment.

IHI has been performing "l/10 scaled mold lofting" except a few sull-scaled loftings which are scaled up from l/10 output to full scale and converting from output prints by the computer system to steel tape templates for, unit working. A large and highly precise drafting-machine and an Electro Photo Marking System made it possible, "l/10 scaled mold lofting" - at IHI.

2.1 Objective Hull Pieces for the N/C Machine (continued)

An Electro Photo Marking System (called shortly (EPM) was developed more than 10-years ago by marriage of Electronics and Optics. It can work a raw plate in eight (8) minutes. It's principle is the same as the one used by photographers. In EPM System, a film is a raw plate on which powders (called photoner) charged static electricity are scattered, and the object is to be taken in photo and is a nested original pattern in l/10 scale. The original pattern is expanded by a very precise lense into l/l scale. The precision of the printed pattern is good enough for the hull pieces.

On the other hand, neither a large drafting machine nor a precise marking equipment piece-is provided at Levingston. In addition, skilled loftsmen are scarce. From these stated reasons, the N/C burning machine is supposed to be very important and very vital at Levingston.

4) Re-arrangement of supporting area of objective pieces for the N/C machine.

The work load of the N/C machine at Levingston shall become more increased through the construction of the bulkers as described in the previous chapters. Moreover, a consideration for "machine-down" of the most vital machine shall be urgent; so that Levignston started thinking of shifting a flat plate (square shaped) from the N/C machine to the flame planer and/or hand cutting. It shall be recommended.

Table 1 OBJECTIVE HULL PIECES FOR N/C MACHINE

| Objective Pieces \ Company | LEVINGSTON | IHI-AIOI SHIPYARD (F-32) |
|---|---|---|
| WEB PLATE (HOLD) | | |
| FLOOR PLATE (HOLD) | | N/C BURNING |
| MAIN GIRDER | | 117 PLT |
| WEB PLATE (OTHERS)<br>FLOOR PLATE (OTHERS)<br>GIRDER (OTHERS)<br>BKT | N/C BURNING | N/C DRAWING<br>↓<br>ERECTO MARKING<br>↓<br>HAND CUTTING<br>622 PLT* |
| CURVED SHELL | | N/C BURNING<br>240 PLT |
| FLAT SHELL<br>FLAT DECK<br>FLAT WALL<br>FLAT BULKHEAD | | FLAME PLANER<br>606 PLT |
| FLAT BAR<br>FACE PLATE | MATERIAL CUTTING LIST<br>↓<br>HAND MARKING<br>↓<br>HAND CUTTING | N/C DRAWING<br>ERECTO MARKING<br>HAND CUTTING<br>*Includ Above |
| FLAT SHAPE | | MATERIAL CUTTING LIST<br>P<br>HAND MARKING 1900<br>HAND CUTTING |
| CURVED SHAPE | | |
| COLLAR PLATE, ETC. | SHEARING OR<br>N/C BURNING OR<br>HAND CUTTING | MAGNET TRACER OR<br>PHOTO TRACER |

I) Numbers of IHI's columns are the actual plate numbers of" Future-32" constructed at IHI AI0I Shipyard.

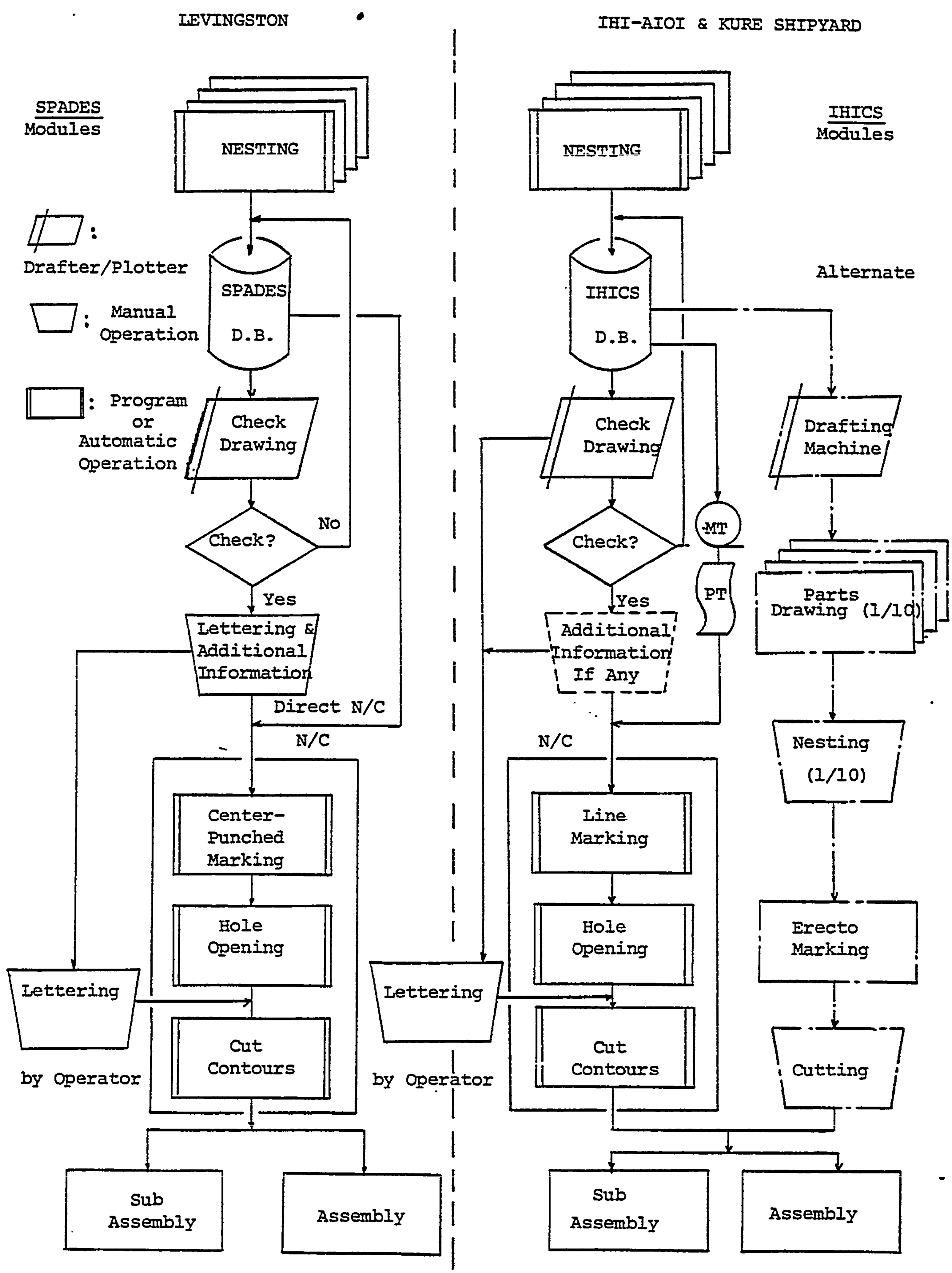
## 2.2 Process Flow of N/C Works (At Present)

A comparison of process flow of N/C works between Levingston and IHI-AI0I Shipyard can be seen in Figure 1. This figure displays a very simple flow from the computer system to the production through the N/C burning machine. The flow controled by SPADES and by IHICS (these are computer-aided hull design systems which have been described in another report "Computer-aided Hull Design System"), is almost the same except for the alternate method of IHI.

In this flow, a few differences between Levingston and IHI can be found. They are: the control method of N/C (direct N.C at Levingston and off-line control at IHI) and the marking method (center-punched-marking at Levingston and line-marking at IHI). These are described in the next chapter.

Drawings for checking purposes at Levingston shall- be improved if a large drafting machine is provided. In this respect, more detailed study has been completed in another report, "Computer-aided Hull Design System".

COMPARISON FLOW OF N/C WORKS (AT PRESENT)



## 2.3 The Function 0f the N/C Burning Machine

A comparison of the function of the N/C burning machines between Levingston and IHI can be seen in Table 2.

Levingston has one C-R-O N/C 3000 System. The five (5) shipyards of IHI have five kinds of N/C burning machines to suit their fabrication methods and a kind of N/C marking machine. IHI has eleven (11) N/C burning machines and three (3) N/C marking machines in total. In IHI-AI0I Shipyard, three (3) N/C burning machines have been provided.

Only a few differences can be seen in the function of the N/C burning machine between Levingston and IHI. A brief explanation on this subject is described as follows.

1) Control Method of N/C

Levingston's control method of N/C is DNC (Direct Numerical Control), DNC is the system which the host computer controls directly the N/C machine, so that no gunched paper tape is necessary. And DNC system shall be more suitable for Levingston, because the host computer is at Ashland Co,, in Kentucky, very far away from Orange, Texas. Therefore it seems to be impractical to get N/C tapes from Kentucky.

IHI's control method is all off-line control. IHI also planned to adopt DNC system, however, it did not occur due to the cost of both initiation and running time. Since IHI has five (5) computer centers near the shipyards, paper tapes or magnetic tapes for N/C are easily provided.

2.3 The Function of the N/C Burning Machine (continued)

2) Bevel Cutting

At Levingston, bevel cutting is performed by the following sequence:

- Programmer defines a surface with bevel cut by the NESTING Program.
- N/C machine stops at both ends of the surface with bevel cut.
- N/C machine operator sets and reset the bevel degree and location.
- Machine restarts.

IHI system has several standardized bevel angles such as $15^{\circ}$, $25^{\circ}$, and $35^{\circ}$. The selection of bevel angle and Ignition/Extinguish are automatically performed by the system without stopping the machine.

If the bevel angle can be standardized at Levingston (even not, the bevel angles other than standard are supposed to be quite a few), the automatic bevel cutting shall be performed by additional feature to the post-processing program for the machine.

TABLE 2 COMPARISON TABLE OF N/C BURNING MACHINE BETWEEN LSCo & IHI

| ITEM | | | LEVINGSTON | IHI | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COMPANY / FUNCTION | | | All ROUND | ALL ROUND | SIMPLE | MARKING | ALL ROUND | ALL ROUND | MULTI.TORCH |
| INSTALLATION DATE | | | April, '75 | Oct., '71 | Sept., '72 | April, '75 | 1974 | Aug., '71 | Sept., '74 |
| MAKER | Burning Machine | | CRO N/C 3000 | Koike,Japan | Tanaka,Japan | Tanaka,Japan | Tanaka,Japan | Tanaka,Japan | Koike,Japan |
| MAKER | Controller | | Kongsberg CNC 500 | Toshiba T-1500C | Toshiba T-1300G | IHI MK-240N | Toshiba T-1500 | Toshiba T-1500 | Toshiba T-40 |
| CAPACITY | BURNING MACHINE | Effective Rail Span | 29'-7" | 31'-2" | 18'-2" | 16'-3" | 39'-0" | 58'-6" | 16'-9" |
| | | EFFECTIVE Rail Length | 111'-0" | 56'-3" | 74'-8" | 74'-8" | 97'-6" | 73'-2" | 58'-6" |
| | | Weight | | 10 MT | 2 MT | 0.7 MT | 8 MT | 13 MT | 1.5 MT *3 |
| | | Gas Pressure Used | $O_2$: 120 PSI Natural Gas: 15 PSI | $O_2$: 9kg/cm$^2$ LPG: 65kg/cm$^2$ | → | | → | → | → |
| | SPEED | Cutting | 2-50 IPM/15-250IPM | 0.4-60 IPM | 2-51 IPM | | 0.4-118 IPM | → | → |
| | SPEED | Marking | 20.83'/Min. | 39'/Min. | 19.5'/Min. | 58.5'/Min. | 39'/Min. | → | → |
| | SPEED | Rapid Transverse | 20.83'/Min. | 39'/Min. | 19.5'/Min. | 58.5'/Min. | 39'/Min. | → | → |
| | | Marking Precision | | ± 1/64" | → | ± 1.5/64" | ± 1/64" | → | → |
| | | Gas Used | Natural Gas | LPG | → | → | → | → | → |
| | TORCH BLOCK | Torch Station | 6(2 Master, 4 Slave) | 4 | 3 | 1 | 2 | 3 | 3 |
| | TORCH BLOCK | Bevel | I.K.V.X.Y | I.K.V.X.Y | I | | I | I.V.Y | I |
| | TORCH BLOCK | Nozzle Tip | Oxweld Made | IHI Made | Koike 106PD | Tanaka | Tanaka 3155A | Tanaka-Curtain | Tanaka-Curtain |
| | TORCH BLOCK | Height Sensing | Fluidic | Fluidic | Fluidic | | Fluidic | Roller | Roller |
| | TORCH BLOCK | Rotating Torch | Equipped | Equipped | | | | Equipped | Equipped |
| | TORCH BLOCK | Ignition Extinguish | Automatic | Automatic | Manual | Automatic | Automatic | Automatic | Manual |
| | TORCH BLOCK | Piercing | Automatic | Automatic | → | | → | → | → |
| | TORCH BLOCK | Marking | Center-punched | Plastic Burned | Zinc Burned | → | → | → | Plastic Burned |
| | | Driving Motor | D.C. Servo | D.C. Servo | → | → | → | → | → |
| CONTROLLER | | Control Axis | X.Y.θ | X,Y1-2,θ1-2 | X.Y | X.Y | X.Y | X.Y.θ | X.Y.θ |
| | | Minimum Dimension Input | 1/64" | 0.1/64" | → | → | → | → | → |
| | | Maximum Dimension Input | 120' | 1230' | → | → | → | 123' | 1230' |
| | | Tape Format | ESSI | EIA-8U | → | → | → | → | → |
| | | Interpolation | Linear and Circular | Linear & Cir. | → | → | → | → | → |
| | | Kerf Compensation | Dial Set | Dial Set | | | Dial Set | → | → |
| | | Reversing | Direct on Path Program Rev. | Dir. on Path Prgm. Rev. | → | → | → | → | → |
| | | Auxi. Function | | 36 | 28 | 32 | 33 | 51 | 27 |
| | | Others | | | | | | | |
| PAST RECORD | CUTTING SPEED | 3/8" T 5/8" | Variable | 51 IPM | 24 IPM | | 30 IPM | 28 IPM | 24 IPM |
| | CUTTING SPEED | 5/8" T 3/4" | | 47 IPM | 20 IPM | | 26 IPM | 26 IPM | 22 IPM |
| | CUTTING SPEED | 3/4" T 7/8" | | 31 IPM | 16 IPM | | 22 IPM | 24 IPM | 20 IPM |
| | CUTTING SPEED | 7/8" T | | 31 IPM | 15 IPM | | 20 IPM | 20 IPM | 18 IPM |
| | | Consideration for Torsion | Water Cooling Cutting Seq., Bridging | Cutting Seq. Wtr. Cooling | → | | → | → | Cutting Seq. Bridging |
| | | Troubles Up-to-date | | | | | | | |
| ADMINISTRATION | MAINTENANCE | Daily | | Operator | → | → | → | → | → |
| | MAINTENANCE | Periodical | | 2 Times/Yr. Maker | → | → | → | → | → |
| | MAINTENANCE | Repairing | | Maker IHI Specialist | → | → | → | → | → |
| | OPERATOR | Number | | 2 | 2 | 2 | 4 | 4 | 1 |
| | OPERATOR | Experience | | 2-3 Years | 3.5 Yrs. | 1.5 Yrs. | 1.5 Yrs. | 3 Yrs. | 1.5 Yrs. |
| Max. Plate No. to be Cut Simultaneously | | | 4 PL(12'-0"*50'-0") | 2 PL(12'*34') | 1 PL(15'*75') | 1PL(15'*75') | 2PL(115*98') | 3PL(16'*46') | 1PL(12'*9') |
| REMARKS | | | DNC | Tokyo - 1 Chita - 1 AIOI - 1 | Chita - 1 | Chita - 1 Yokohama-2 | Chita - 2 AIOI - 2 | Kure - 2 | Kure - 2 |

## 3. Some Recommendations on the Usage of the N/C Burning Machine from IHI

In this paragraph, some recommendations on the subject are presented. In addition, IHI's line marking method and its adaptability to the Levingston present system since it seems to be preferable from the viewpoint of workability by sub-assembly and assembly.

### 3.1 Standardization of Bevel Angle for the Automatical Bevel Cutting

Though this subject is concerned with not only the N/C system, standardization of bevel angle has the possibility for automatical cutting of bevel surface, Since automatical setting of optional bevel degree is very difficult, it is true that the angle has to be set by hand, However, if this standardization has been completed, pretty part of bevel surface can be cut auto-. matically by adding a feature for that to the postprocessing program which is connected to the output from the SPADES system.

Even if the said additional feature is not possible, necessary time for setting bevel angle shall be much saved by standardization of bevel angle,

### 3.2 Re-Arrangement of Supporting Area 'of Objective Pieces for the N/C Machine and a Consideration for "Machine-down"

Since the work load of N/C machine at Levingston is expected to be increased as described in Chapter 1 of this paper, re-arrangement of the subject shall be urgent.

### 3.2 Re-Arrangement of Supporting Area of Objective Pieces for the N/C Machine and a Consideration for "Machine-down" (continued)

From the viewpoint of the workmanship at Levingston it is recommendable to cut hull pieces by N/C machine as far as possible. However, in case of over work load at N/C machine, it is recommendable that a flat plate such as main deck plate is shifted from the N/C machine to the flame planer. In addition, the scaled mold lofting (l/10 or l/12) is recommendable to be established with the aid of a large drafting machine; because making templates in full scale from the scaled drawing (l/10 or l/12) is possible when "machine-down" of N/C continues for awhile. In this concern, more detailed description has been presented in another report "Computer-aided Hull Design System.

## 4.0 Line Marking Method of IHI System (For Reference)

Levingston's N/C system adopts center-punched marking system. This system can work (punch) points with several variations of intervals between them. From the viewpoint of workability at sub-assembly and assembly, this marking system shall not be so easy for production people to fit pieces on the marked (dotted) line. In fact, production people are seen marking a continuous straight line by stretching a thread. In this concern, it seems to be interesting to introduce IHI's line marking method for reference.

There exists two (2) kinds of line marking methods in IHI's system. One is to burn zinc powder by a working torch to a steel plate. Another-is to burn plastic powder. The clear continuous lines' (l/16" in boldness) can be marked with a speed of about 40' per minute. Comparing with the center-punched marking, it-might have a demerit to be faded away during the fabrication process. However, no particular consideration is requested at IHI. More detailed information on this marking system -is presented in the following table.

LINE MARKING DEVICE IN IHI SYSTEM

| | ZINC POWDER | PLASTIC POWDER |
|---|---|---|
| Price of One Device (Price in Japan) | 400,000 Yen ($2,000) | 800,000 Yen ($4,000) |
| Running Cost | Powder<br>3 Yen per 3'-3" of Marking<br><br>Nozzle Tip (per one)<br>25,000 Yen ($125) | Powder<br>3 Yen per 3'-3" of Marking<br><br>Nozzle Tip (per one)<br>25,000 Yen ($125) |
| Maintainability | Easy | Very Complex |

Adaptability to Levingston's System

Some additional work shall be requested for adoption of the equipment to the present Levingston machine as follows:

1) Fuel gas, oxygen, Water and air must be supplied for the working torch.

2) Postprocessing program must have a signal of marking ON/OFF. This function is supposed to be satisfactory in the present program.

EPILOG:

This report was made through the investigation and discussions with Levingston's personnel by IHI. IHI hopes that Levingston continues a study on the subject matter for the future betterment along with the recommendations described in this paper from IHI.

# APPENDIX J

## LSCO STUDY AND COMPARISON OF SPADES VS. IHI SYSTEM

LEVINGSTON SHIPBUILDING COMPANY

Technology Transfer Program

TASK 2 Engineering and Design

Sub Task 2.1 Computer-Aided Design Systems

# STUDY AND COMPARISON OF SPADES VS. IHI SYSTEM

E. E. MAYER

4/25/79

## INTRODUCTION

In an overall comparison of the SPADES system and the IHI system for computer-aided design, the SPADES system comes in second only due to the quanity of programs that compose the entire IHI N/C system.

Considering production aids, the SPADES system is equal to the IHI system, and becuase of ease in user coding, the SPADES N/C production oriented system is considered the better of the two.

Definitions :

S.P.A.D.E.S. - Ship Production and Design Engineering Systems

I.H.I.C.S. - Integrated Hull Information Control Systems

Appendices:

Appendix 1 - Spade System Ship Production & Control Module
Cali & Associates Inc.

Appendix 2 - Spades System - Engineering Detailing Module
Cali & Associates Inc.

COMPARISON ANALYSIS

Comparison Tab1e

| | APPLICATION | SPADES | IHICS |
|---|---|---|---|
| 1) | Hull definition **and** data base creation | *Lines fairing<br>*Hulload<br>*Demo | *Lines fairing<br>*Shell landing<br>*3-D process<br>*Section design sub-system |
| 2) | Production Lofting | *Parts generation<br>*Parts separation<br>*Plate development<br>*Nesting | Production Engineering sub-system consisting of:<br>*"Line" system for nesting w/manual and interactive graphics by "cards".<br>*Part generation |
| 3) | Ships production and control programs | *SPAC (Ship Production and Control ) | *Part data base administrative program<br>*Piece data assortment program |
| 4) | Production and Lofting assistance programs | Mfg. aids module for:<br>*Frame bend offsets<br>*2 dimensional pin heights<br>*Girth length table<br>*Rol1 set templates<br>*Meld loft offsets | "LODACS" system for:<br>*3 dimensional frame bending (offset info only for twist-<br>*Mold loft offsets (from data creation sub-system)<br>*Part data base administrative program and shell program produce templates for shell plate bending and pin jig heights |

| | APPLICATION | SPADES | IHICS |
|---|---|---|---|
| 5) | Design engineering and hull calculation programs | Hull calls for:<br><br>*Bonjean curves<br><br>*Hydrostatics<br><br>*Longitudnal strength<br><br>*Tank capacity and sounding and ullage<br><br>*Trim calculations<br><br>*Damage stabi1ity<br><br>*End 1aunching | Specs for:<br><br>*Bonjean Curves<br>*Hydrostaties<br>*Longitudinal strength<br>*Tank capacities w/sounding and ullage<br>*Trim calculations<br>*Damage stability<br>*Launching calculations<br>*Grain heeling moment<br>*Sea trial data |

6) Programs that IHICS has that SPADES does not have are "z VIBRA" for vibrational analysis and "Z PLATE” for structural analysis. These, or similar, programs are available to LSCo from their sources.

## Explanation Of Comparison Table

(1) The Hull Definition modules compare equally since the end product or output comparisons bear close resemblance. Both FAIRING modules have excellent splines and produce very fair lines. However, the SPADES system utilizes more control line output for assistance in development of other moduies. Also, skewed planes may be generated for cant framing and additional frames may be loaded for shell master butts.

The HULLOAD program is the SPADES module that defines shell landings of stiffeners, seams, decks, longitudinal bulkheads. HULLOAD also defines stiffeners and seams on decks. flats, and longitudinal bulkheads.

IHI generates this information with its I.H.I.C.S. shell and panel landing modules, which along with-the line module, comprise the data base. Without actual coding examples of the IHI system, a true detailed comparison is not possible. However, based on other available examples, coding the SPADES system in less difficult than coding the IHI system.

DEMO (Detail Engineering Module) and IHI's I.H.I.C.S. production engineering system (Integrated Hull Information Control System) both provide for the loading of structural details into the data base. The SPADES DEMO module (see enclosure) is a powerful tool which enhances the HULLOAD program and allows for structure definition loading in all planes including transverse and skewed. DEMO also places the emphasis of part definition within the engineering group and consequently allows part generation personnel to concentrate on parts separation.

The DEMO module can also provide drawings that are suitable for issue with hand finishing done by a drafter. The IHI system is capable of performing an equal task, but an accurate definition of how, when, and which module performs this function is not explicit in the description material IHI has provided.

(2) The PRODUCTION and LOFTING N/C modules, when compared based on available I.H.I.C.S. input information, shows the SPADES production module to have an easier input format and to be almost equal in output information. (See appendices No. 1 and No. 2)

Parts generation, plate development and other similar modules compare as to the assistance offered to production. However, the IHI group -utilizes more output information than the LSCo group needs at present.

The nesting modules offer no real comparison, as the SPADES system is totally interfaced with the data base and the IHI system uses a manual input of parts information to generate marking and burning tapes. Both systems have an interactive graphics capability in the nesting cycle.

3) The ships production and control modules are difficult to compare, as the IHI N/C system performs such tasks under different modules. However, the overall output far exceeds what Levingston or SPADES can generate. IHI adheres to the policy that Production Control and Planning system utilizes every means necessary to achieve and maintain total control. From the data submitted, it is concluded that data input is mainly performed manually using output information found in the data base.

IHI produces a cutting list, parts list, and piece drawing for every item on a ship whether processed by numerical control or manually .

The SPADES SPAC module (Ships Production and Control) has not been used nearly as extensively as the corresponding IHI modules. SPAC is a new module in use at this time only at National Steel and Shipbuilding Company and by Cali and Associates. The SPADES SPAC system utilizes the full data base for reporting and its limitations are set only by user option. This module provides a large growth potential.

4) In the area of Production and Lofting assistance, the IHI and SPADES systems are almost completely equal. Each offers the roll set templates, frame bending, pin jig heights, girth length tables, and mold loft offset talbes necessary in N/C shipbuilding.

The SPADES system module manufacturing aids interfaces the data base from which it pulls the output information requested, IHI use different sub-systems to gather required information and not all of them actually access the data base for data generation. In fact, the three-dimensional frame bending module, called LODACS, uses offset information from Fairland and other modules for input into the LODACS module which is a stand-alone module. The output information generated by LODACS for frame bending and end cuts is of exceptional qua1ity.

5) The Design Engineering and Hull calculation programs of the IHI system is superior to the SPADES system in breadth and completeness, especially as applied by IHI. SPADES Hullcal does have the advantage of direct access to the data base, which simplifies coding . The IHI SPECS (Ships Preliminary and Exact Calculations System) requires manual preparation of input as it is a stand-alone module.

The SPADES output format is now out-dated and the Levingston Design Department has chosen to use SHGP (Ship Hull Characteristics Program). However, with a soon to be imp1emented Fortran subroutine, the Hullcal output should be more acceptable to regulatory bodies requirements and needs. IHI SPECS is a complete hull calculation system even including calculation of ship sea trial criteria.

6) IHI's structural analysis and vibrational analysis programs Z Plate and Z Vibra, are stand-alone modules similar to several programs used by Levingston but produced by other companies. The programs are not comparable to a SPADES module as SPADES is not intended to be involved with Desing Engineering analysis.

## CONCLUSIONS

In summary, the IHI N/C system and the SPADES N/C system are both very good. The IHI system is fully utilized to the best advantage of the IHI shipbuilding complex while the SPADES N/C system utilization at Levingston is limited by a lack of implementation and facilities.

The comparison of those N/C modules that actually duplicate the old style lofting and template making methods would actually give SPADES the advantage as the input coding of SPADES is much easier. Also, SPADES fully utilizes the data base set up with the Fairing and Hulload modules.

Implementation of the IHI system at Levingston is not necessary because the SPADES system currently utilized is more than adequate for present and future needs. All SPADES modules access the data base for ease in generating input data.

Overall, both systems serve the intended functions. IHI utilizes Computer-aided Design and N/C to their maximum capabilities which is one reason they are one of the world's foremost shipbuilders.

CALI & ASSOCIATES, INC.
3101 37th. STREET, SUITE 130 METAIRIE, LA. 70001 Phone (504) 835-264

Consultants for Engineering
and Marine Industrial
Computer Applications

APPENDIX 1

# SPADES SYSTEM

## SHIP PRODUCTION & CONTROL MODULE

(Preliminary Description)

# INTRODUCTION

The use of extensive modular construction in shipbuilding, combined with the increased use of Numerical Control, has greatly improved in the last decade the efficiency of the industry.

In order to properly utilize these techniques, it was immediately apparent, however, that more and better planning was necessary.

The planning effort, per se, is neither too difficult nor too costly. The collection and updating of the data needed to generate the required reports is both difficult and costly, in order to obtain a reasonable degree of accuracy,

The The 'ship Production and Control (SPAC) Module' of the 'SPADES' System **is** designed to achieve in this area the following goals:

1. Reduce man-hours for data collection.
2. Improve the accuracy and timeliness of the reports.
3. Reduce ship construction costs by reducing errors and misinformation in the shops,

The 'SPACE' Module covers at the present only the hull construction. It is intended-t, in parallel with the development of modules to handle the design and production of other ships' systems, the 'SPAC' Module will be expanded accordingly.

## DESIGN CRITERIA OF THE 'SPAC' MODULE

Since the 'SPAC' Module properly falls in the category of management in formation systems, the basic criteria applicable to this type of system must be respected as follows:

1. The module must allow the collection of independent data at the origination source and make it immediately available to all interested shipyard functions.

   As an example, for instance, assembly boundaries and schedule starts can be inputted directly to the system and the 'master erection schedule' report generated immediately after for dissemination.

2. All applicable data generated by other modules of 'SPADES' must be collected and used by the 'SPAC' Module without any user intervention,

   This feature is the main justification for the development of the module, and the following is a partial list of examples:

   .Allocation to the proper assembly and sub-assembly of all pieces generated through use of 'PARTGEN', 'PARTSEP' 'PLATDV' or 'MANF AID (frame bending).

   *Processing time for N/C burning tapes and flame planer sketches.

   .Unit weight of individual pieces and weight and centers of gravity of assemblies and sub-assemblies.

   *Length and nesting within standard lengths of shapes of the various individual shape pieces.

   - Cross reference between assemblies due to the nesting into a plate of pieces belonging to different assemblies.

   - Bulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.

3. Revsion control is maintained by the system for all the issued reports generated.

   A summary report can also be generated, showing at any one point in time the current valid revisions of all the issued reports.

4. Any change of the independent data or other data used by the system must generate an exception report indicating which of the reports are affected by the change, so that the user can initiate the proper request.

   For example, if planuing changes require different boundaries for any one assembly, the module must automatically update the allocation of all pieces effected by the change of boundaries, and give a report indicating which reports must be requested for re-issue.

5. Exception reports can be generated to indcate to the uaser at any point in time which pieces for any **one** particular drawinghavenot as yet been defined, or any material deficiencies.

6. The system must allow the introduction of data at levels other than the optimum, to override or enrich the **data** base, in order to be able to generate complete reports at anytime.

The Appendix contains the basic data flow for the module, a brief description of the input needed, and some examples of the reports generated by the system. The examples of the reports are simulated in this preliminary description, and they will be changed as the development of the module proceeds.

## CONCLUSION

The purpose of this preliminary description is to disseminate among all potential users the features and the capabilities of the module **as** they are conceived by Cali &Associates,. **Inc.**

It is hoped that a review by the shipyards will provide us with the very much needed input and comments for incorporation during the development. Specific comments regarding the size and format of the data used by each shipyard **as** it is applicable to this module will be very helpful in avoiding future incompatibilities and/or restrictions.

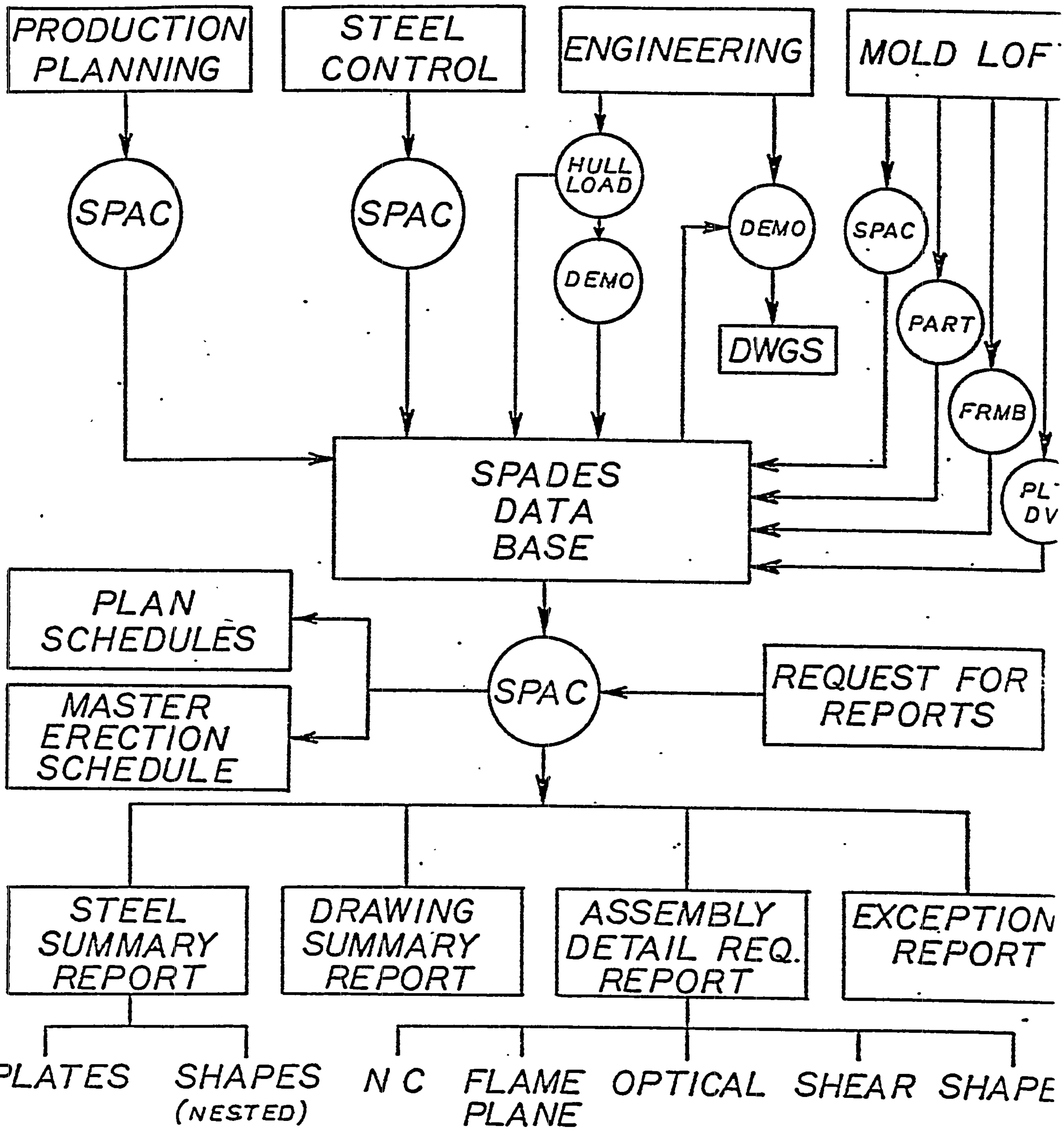
# S P A D E S  S Y S T E M

## SHIP PRODUCTION & CONTROL MODULE

## APPENDIX

# SPADES SYSTEM

## DATA FLOW FOR SHIP PRODUCTION AND CONTROL MODL



## TYPES OF INPUT & RESPONSIBILITY FOR THEIR PREPARATION BY SHIP YARD FUNCTION

1. Production Planning

   a) Limiting boundaries of planned assemblies (units) and sub-assembly breakdown, if any. The system will always assume that ship's surface, such as deck, webs or shell will constitute a sub-assembly,

   b) Planned start date for processing each assembly.

2. Steel Control

   a) Final steel bill. This is intended to mean the steel take-off bill as modified for utilization of stock and/or standardization of plate size, The various items in the various steel bills will carry a unique stock number compatible with the shipyard system.

   b) Storage location of various items in the steel bill will be given to the system upon receipt of the steel.

3. Engineering

   a) Loading of the data base. Through the detail engineering module, the data baseloading capabilities will be expanded, allowing at the same time the easy generation of detail drawings, As part of this activity, engineering will also update, as needed, database libraries of standards (brackets, chocks, etc.), shapes, characteristics, and associated cut-outs.

   b) Drawing list and associated range of pc. mks. used in each drawing. This will allow the system to generate exception reports calling attention to pieces not generated at any one point in time;

4. Mold Loft

   a) Through the use of 'PARTGEN', 'PARTSEP' and 'PLATDV', the loft will enable the system to allocate the pieces thusly generated to the various assemblies and sub-assemblies. Provision will be made for identifying drawings, pc. mk. and beveling detail, and also applicability of a part to another area of the ship.

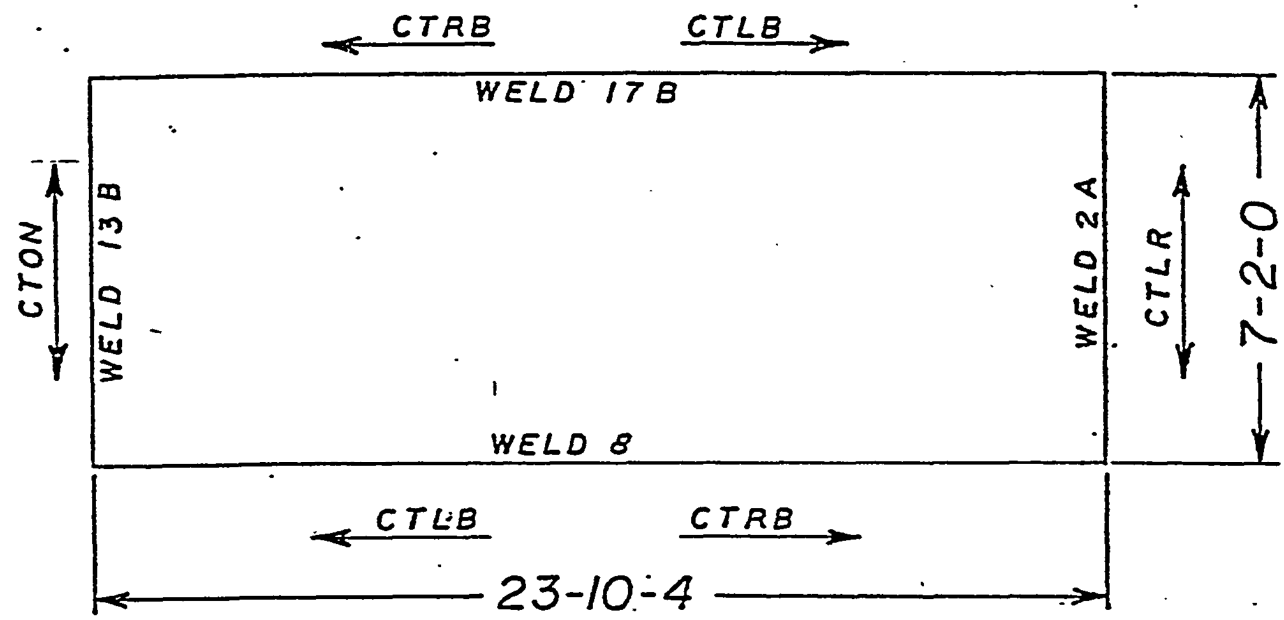
b) Through the use of 'MANF AID' (frame bending), all shapes, whether straight or curved, will be identified and allocated to the proper assembly, The Frame Bending Program will be modified to easily do that for all flat surfaces.

c) Through the use of the Ship Production and Control (SPAC) Module, the loft will input to the System all the miscellaneous pieces not otherwise identified.

# SHIPYARD NAME

# EXACTOGRAPH SKETCH

SHIP ______________ HULL NO. ______________
JOB ORDER NO. ______________
ASSEMBLY ______________
SUB ASSEMBLY ______________
DWG. NO. ______________ PC. NO. ______ DET NO. ______
PLATE SIZE ______________ QTY REQD.
PLATE STOCK NO. ______________




TAPE NO. 301376-307-1 EXACTOGRAPH

CALI & ASSOCIATES, INC.
3101 37th. STREET, SUITE 130 METAIRIE, LA. 70001 Phone (504) 835-2641
Consultants for Engineering and Marine Industrial Computer Applications

. APPENDIX 2

# SPA-DES SYSTEM

## ENGINEERING DETAILING MODULE

(Preliminary Description)
(DEMO)

# OBJECTIVES

The main purpose of this module is utilize the time and effort spent during. the detail design phase for numerical description of the ship structure. During this phase, all. structural details are defined, and if these definitions can be re-corded **on** the database, interpretation of the drawing and the possibility of errors downstreams during part generation can be greatly reduced, Greatly expanded database loading loading capabilities will provide information over and above the geometrical part generation requirements which can be used by the pIanning and control module or other ship's systems.

As the volume of information. the database increases and the base be-comes more comprehensive verification of loaded data becomes more and more difficult. 'The quickest way of verificationi by drawing. Therefore, a simple and easyway of accessing the data base with a few commasds is needed to auto-matically output all loaded data of a particular surface in to a composite drawing,

If this drawing capability is achieved; only a few options are needed to **extract** partial drawings for all kinds of purposes. Structural drawings can be complete, with the exception of lettering and dimensioning. Background drawings for **ar-**rangements and composites can be produced with just a few commands.

# PREREQUISITES

In order to make this module an officient tool for detailing, the loading capabilities of the data base will be expanded. The 'H'JLLOAD' Module will be capable of loading traces and details in transverse, plan and elevation views. Additional information on all surfaces will include:

a) Stiffeners and their end connections
b) Seams and plate thickness associated
c) Brackets and chocks
d) All access holes, including face bars
e) Inside contours, as defined by web frames.

All through members affecting other surfaces must be handled by 'HUILOAD' Local details will be defined by 'DEMO'.

## OPERATING PROCEDURE

Although the module's primary task is to aid in loading the data base, direct loading capability is not conceived. The actual loading of the **data** base is reserved for the group of people responsible for loading the data base through 'HULLOAD'. This is to preserve the integrity of the data base by concentrating the rersponsibility onto one person, or one group of people. However, to avoid having the 'HULLOAD' people recode all the definitions Module 'HULLOAD' will have the capability of executing the same input deck, ignoring irrelevent commonds, but executing and loading the detail specifications,

The application of the module within the ship design effort is seen as follows:

1. Fairing and loading of the major structure through 'HULLOAD'
2. **Extract** a drawing of the surface containing outlines and through **members** through 'DEMO'.
3. Load repetitive patterns of stiffeners and seams through 'HULLOAD',
4. Extract a new drawing through 'DEMO' containing all loaded details.
5. With 'DEMO', add and modify details of stiffeners, seams, holes and-brackets, resulting in:

   - new drawing, complete with the exception of lettering and dimensioning
   - An input deck defining the details executable by 'HULLOAD'
   - An entry in a data base record which contains all input decks -- that are generated by 'DEMO' and must be executed by 'HULLOAD'

6. When the design is completed, control is transferred to 'HULLOAD' The input deck is executed, loading the details. The entry of the final step above is deleted.
7. Revisions:
   a) If the drawing is not released as yet, the revision may be added to the 'DEMO' input deck executing '5' and '6'
   b) if the drawing is released and lettering and dimensioning has been added, revisions **are** effected through 'HULLOAD' only,
8. After the structural details have been loaded, drawings for other disciplines such as arrangements and composites may be called.

## INFORMATION DEFINED BY 'DEMO'

**Only** local details are defined through 'DEMO'. Details are defined as follows :

| | | |
|---|---|---|
| 1. Stiffeners: | Symbolic name | s ABC P/S |
| | Contour definition | |
| | Shape code number | |
| | Orientation (near side or far side) | |
| | End connections (lap, snipes, **knuckles).** | |
| 2. Seams: | Symbolic name | J ABC P/S |
| | Contour definition | |
| | Welding detail (bevel and gap) | |
| | Thickness on both sides. | |
| 3. Holes : | Symbolic name | H 123 P/S |
| | Contour definition | |
| | Thickness, width and offset of face bar.. | |
| 4. Brackets: | Symbolic name | B 123 P/S |
| | Contour definition or standard detail identification | |
| | Thickness | |
| | Width and thickness of flange. | |
| 5. Inner Lines: | Accessible only as a contour | |
| | Identified by 'INNL' | |
| | Contour definition | |
| | Width and thickness of face bar. | |

PL. MKS (SEE. PLANNING)

## PROGRAM CAPABILITIES

Options with automatic drawing of data base contents:

4) Scales
b) Windowing
c) with or without shapes ('T' 'L' etc.)
d) With **or** without cut-outs and **snipes**
e) With or without stiffeners and seams on the surface
f) Include background frame or deck
g) Pen selection for turret machines
h) Line selections of different types of dashed lines.

2. Automatically included as drawing standard:

a) A standard grid surrounding the entire drawing
b) Center line and/or base line, if part of the drawing.

3. Programming capabilities and language ‘as close to 'PARTGEN' as passible, so that people programming 'PARTGEN' and 'DEMO' are interchangeable. All 'PARTGEN' tools such as Math, Contours, Symbolic Calls, Loops and Reps will be available.

4. Added Commands for detail definition:

a) STIF
b) SEAM
c) HOLD
d) BRKT
e) INNL

5. Looping capability:

programming of similar surfaces by modification to typicalcsurface such that only changes have to be redefined.

TAPE NO. 208002

Standard Grid for All Drawings

## EXAMPLES

1. Floors 46 through 53 are similar, with the exccption of the location of the holes. The sample input deck draws two floors as typical configurations and loads al1 other floors by continuously modifying the location of the holes-

2. Bulkhead 31 is preloadcd by 'HULLOAD' with most 'of the vertical stiffeners.

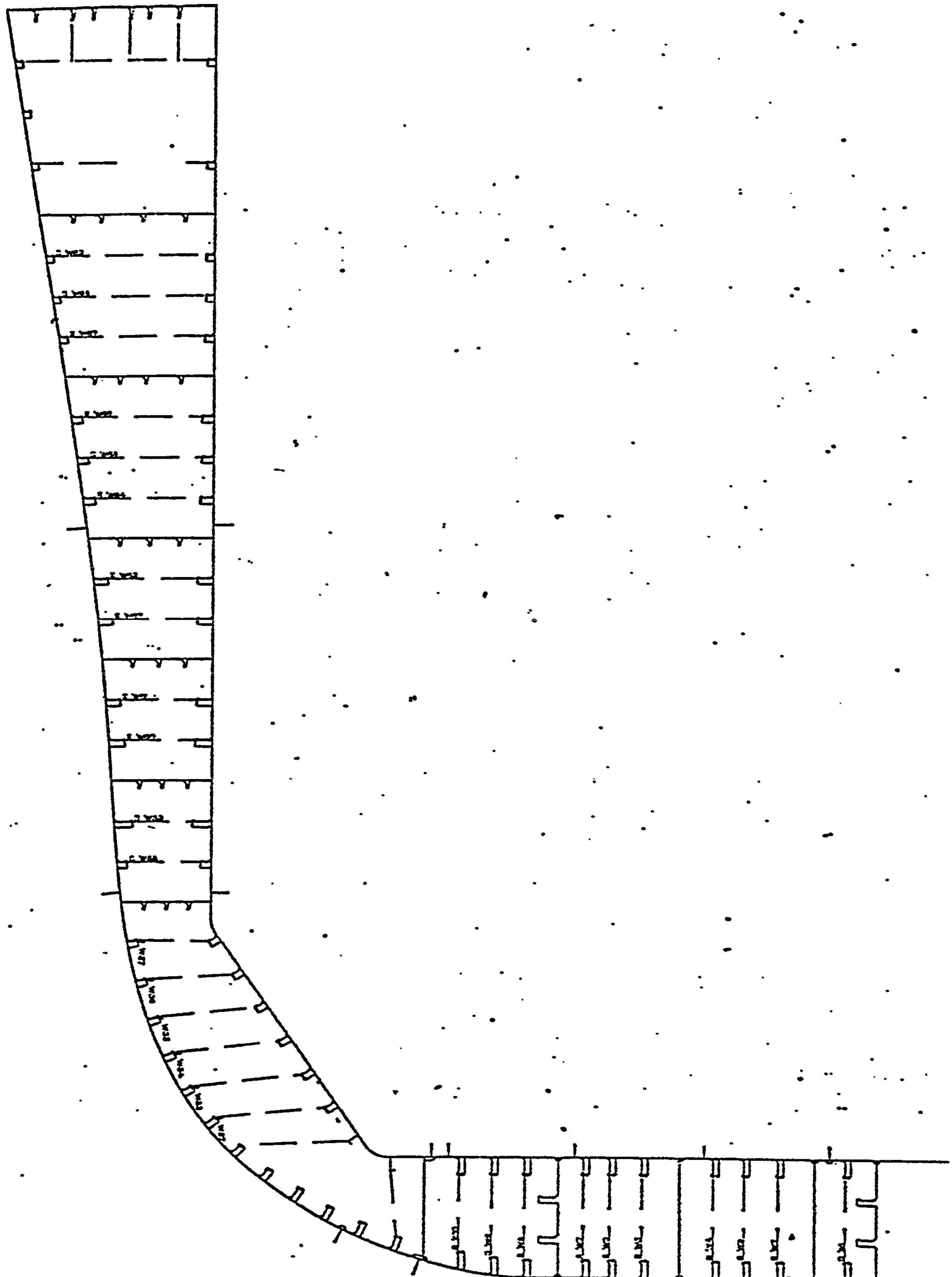
   Stiffeners T9, TIO and Tll are modified by 'DEMO'. Access door and' seams are added.

3. Web frames 49 through 52 involved quite extensive calculations and developments showing the method of programming details.

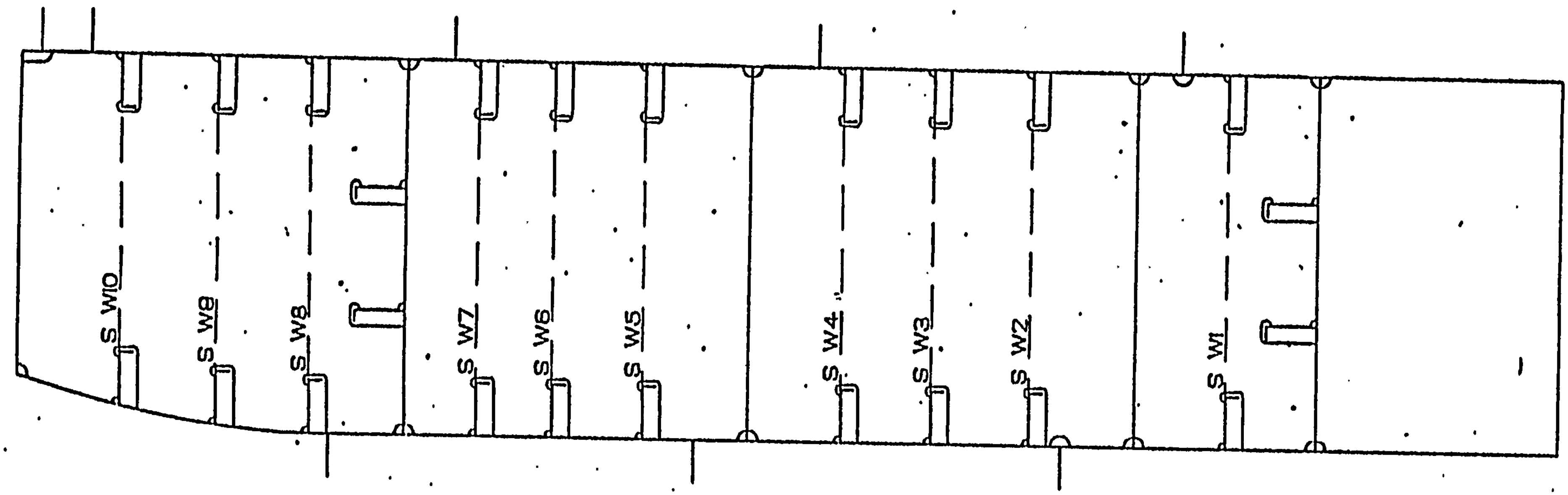
```
******  EXAMPLE 1 :  INPUT DECK TO DRAW CONTENTS OF THE DATA BASE
                     WEB FRAMES 46, 50, 52
-----------------------------------------------------------------------

*JOB LNG DEMO              N      9001                                      12900100
INPS                       N      9001                                      12900100
TRSV                 FWD   F 46.       F 50.      F 52.                     12900100
OPTN      SCAL       CUTS              V  48.                               12900100
INPE                                                                        12900100
```

```
******  EXAMPLE 1 :  INPUT DECK DEFINING AND LOADING DETAILS FOR
                     FLOORS FRAMES 46 THROUGH FRAME 52
-----------------------------------------------------------------------

*JOB LNG DEMO              N      9002                                      129002000
INPS                       N      9002                                      129002000
-----------------------------------------------------------------------
          COMMAND DEFH --  DEFINING STANDARD HOLES
-----------------------------------------------------------------------
DEFH                              30        15         7 8            1     129002000
                                  30        16         9              2     129002001
                                  12         6         3              3     129002001
TRSV                 FWD   F 46.     F 50.      F 52.                       129002002
ADDP                       D TT      L 15                       2     1     129002002
                           M         P ORG                              2     129002003
-----------------------------------------------------------------------
          COMMAND LIMT - DEFINING LIMITS OF DRAWING
-----------------------------------------------------------------------
LIMT                       P        2          P        1                   129002003
OPTN      SCAL       CUTS             V  32.                                129002004
-----------------------------------------------------------------------
            START DEFINING DETAILS ON FRAME 46
-----------------------------------------------------------------------
ADDP                       L L1      S 1          1               3     129002004
                           P     3                          -2    4     129002005
                           M         L L1        1 3      -1 6    5     129002005
                           M         S CVK       1 3       1 3    6     129002006
                           D TT      S CVK      -1 3       1 3    7     129002006
                           D TT      L L1       -1 3      -1 6    8     129002006
                           L L1      S 2          1               10    129002007
                           P    10                          -2    9     129002007
CNTR                                                                    129002008
CORN                       P     3                                      129002008
                           P     4                                      129002008
```

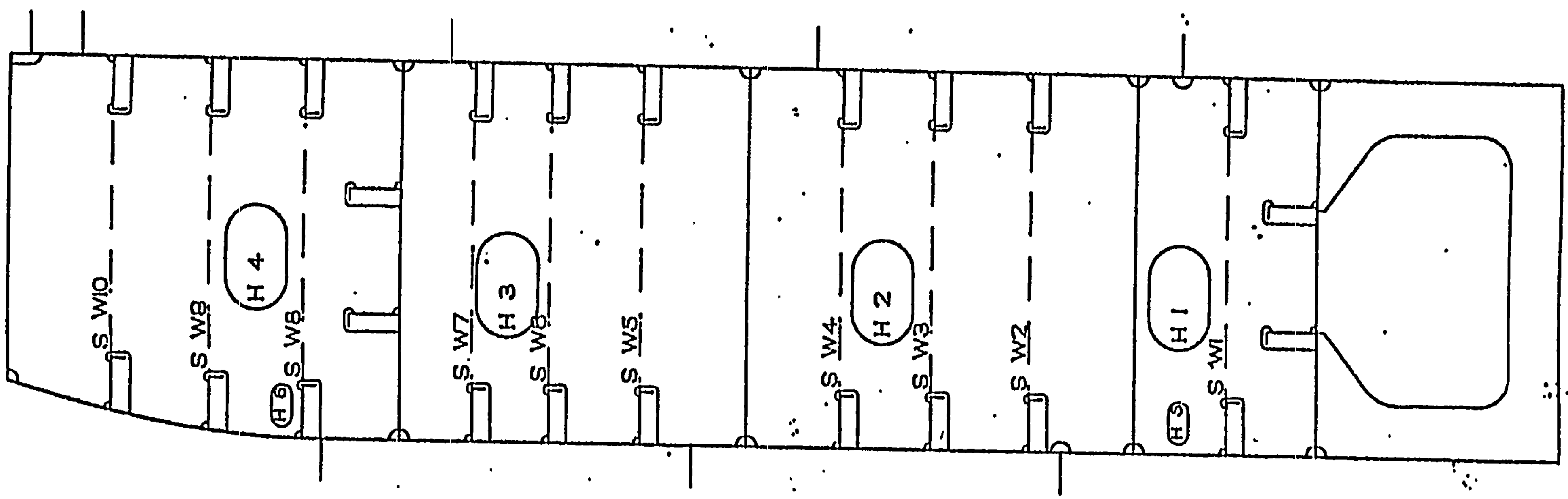
```
                    P        5                   9                     12900200
                    P        6                   9                     12900201
                    P        7                   9                     12900201
                    P        8                   9                     12900201
                    P        9                                         12900201
                    P       10                                         12900201
CTRE    HOLD                           1                 H  1          12900201
MIDN                 M                                                 12900201
SPLT                           L L7                      S 4      11   12900201
                               S 14                      S 6      12   12900201
HOLD                     221   Y       11                H  3      2   12900201
                         315   Y       12                H  4      2   12900201
------------------------------------------------------------------
     LOAD DETAILS ON FRAME 46
------------------------------------------------------------------
LOAD                           F 46.                                   12900201
------------------------------------------------------------------
    DEFINE DETAILS ON FRAME 47 THAT ARE DIFFERENT FROM FRAME 46
------------------------------------------------------------------
SPLT                           L L7                      S 5      11   12900201
                               S 13                      S 8      12   12900201
HOLD                     221   Y       11                H  3      2   12900201
                         221   Y       12                H  4      2   12900201
LOAD                           F 47.                                   12900201
SPLT                           S 11                      S 8      12   12900201
HOLD                     221   Y       12                H  4      2   12900201
LOAD                           F 48.                                   12900201
SPLT                           L L3                      S 2      13   12900201
                               L L11                     S 8      12   12900201
HOLD                     221   Y       13                H  2      1   12900201
                         221   Y       12                H  4      2   12900201
LOAD                           F 49.                                   12900202
SPLT                           S  6                      S  5     11   12900202
                               L L11                     S  9     12   12900202
                               S 13                      S 12     14   12900202
HOLD                     221   Y       11                H  3      2   12900202
                         221   Y       12                H  4      2   12900202
                         315   Y       14                H  5      2   12900202
LOAD                           F 50.                                   12900202
ADDP                           S 12              9           6    15   12900202
HOLD                       9   Y       13                H  6      3   12900202
                    P     15 P         15                H  7      3   12900202
LOAD                           F 51.                                   12900202
SPLT                           S 10                      S  9     12   12900202
HOLD                     221   Y       12                H  4      2   12900202
                         3 0 9.   3211 8                 H  5      2   12900202
LOAD                           F 52.                                   12900202
DLET                                                     H  6          12900202
                                                         H  7          12900202
HOLD                     3 0 9    34 9 4                 H  5      2   12900202
LOAD                           F 53.                                   12900202
INPE                                                                   12900202
```



Example 1: Webframe 52
Drawing after 'HULLOAD' only




Example 1: Floor 52
Drawing after 'HULLOAD' only

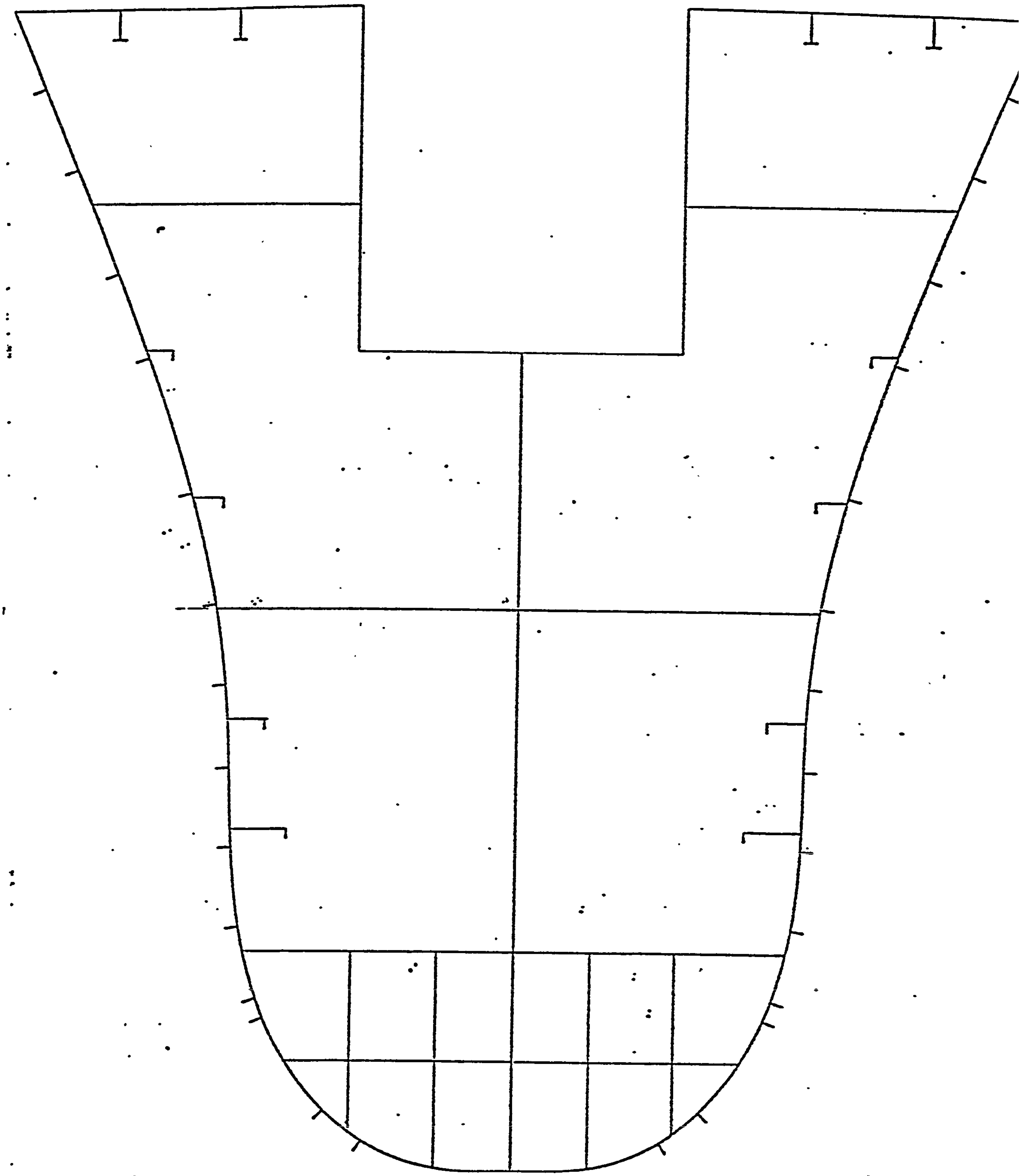



Example 1: Floor 52
Drawing after detailing by 'DEMO'.

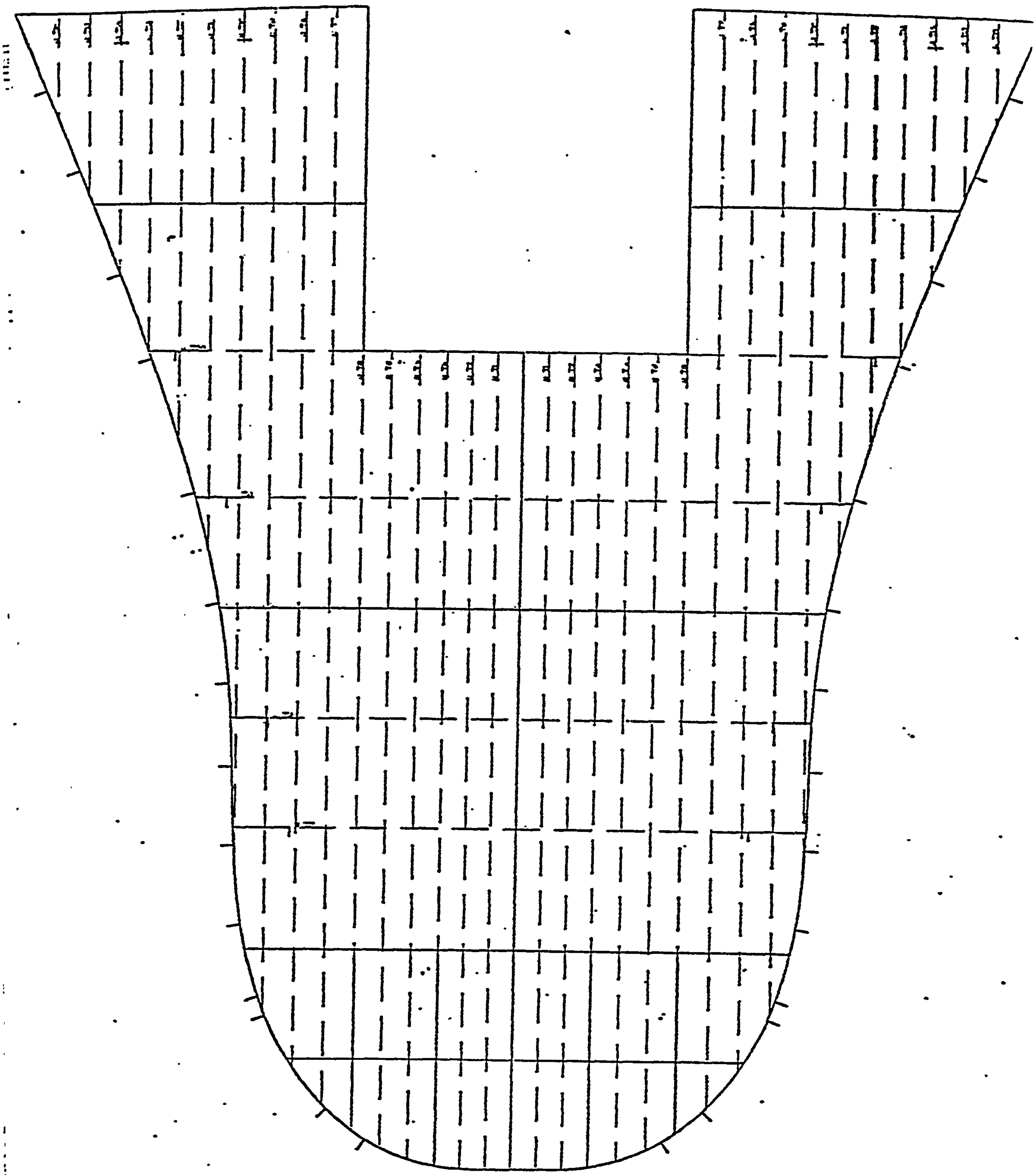
****** EXAMPLE 2 : INPUT DECK FOR DETAILING OF BULKHEAD 31

```
------------------------------------------------------------------
*JOB LNG DEMO          N     9010                                    12901000
INPS                   N     9010                                    12901000
------------------------------------------------------------------
       AUTOMATIC DRAWING FROM THE DATA BASE
------------------------------------------------------------------
TRSV              FWD   F 31.                                        12901000
OPTN     SCALNTEE                  48.                               12901000
------------------------------------------------------------------
       START DETAIL DEFINITIONS
------------------------------------------------------------------
CNTR     CALC                                                        12901000
SHEL              P+     M                                           12901000
SLPE2                  Y   2436                              10 1    12901000
SLPE2                  Y   1823                              11 1    12901000
CTRE     NOCT                                                        12901000
CNTR     CALC                                                        12901000
DECK              P+     D MDK                                       12901000
SLPE2                  Y   1821                              21 1    12901000
    2                  Y     2026                            22 1    12901000
    2                  Y   2436                              20 1    12901000
CTRE     NOCT                                                        12901000
ADDP                     D 46F      P ORG                    13      12901000
                         D 28F      P ORG                    14      12901000
                         D 2ND      P ORG  1          2436    1      12901000
                        P       1                    -1313 31        12901000
                        P       1                     1313 32        12901000
                        P      31             52021          33      12901000
                        P      32             52021          34      12901000
                        P       1            11 9      2 5    2      12901000
------------------------------------------------------------------
      ACCESS DOOR -
------------------------------------------------------------------
CNTR                                                                 12901001
CORN                    P      32                                    12901001
                        P      34              13 8                  12901001
                        P      33              13 8                  12901001
                        P      31                                    12901001
CTRE     HOLD                 6          5           H D1            12901001
------------------------------------------------------------------
       MODIFY STIFFENERS
------------------------------------------------------------------
PNCH3                   P      20            P      2                12901001
STIF  502    LAPCSNPE                                ST22   P        12901001
PNCH3                   P       1            P     10                12901001
STIF  503    SNPESNPE                                ST12   P        12901001
PNCH3                   X      20-Y       20 X     10-Y     10       12901001
STIF  503    LAPCSNPE                                ST12   S        12901001
CNTR                                                                 12901001
MANU                    P      22                                    12901001
LINE                    X      13    2026                            12901001
```

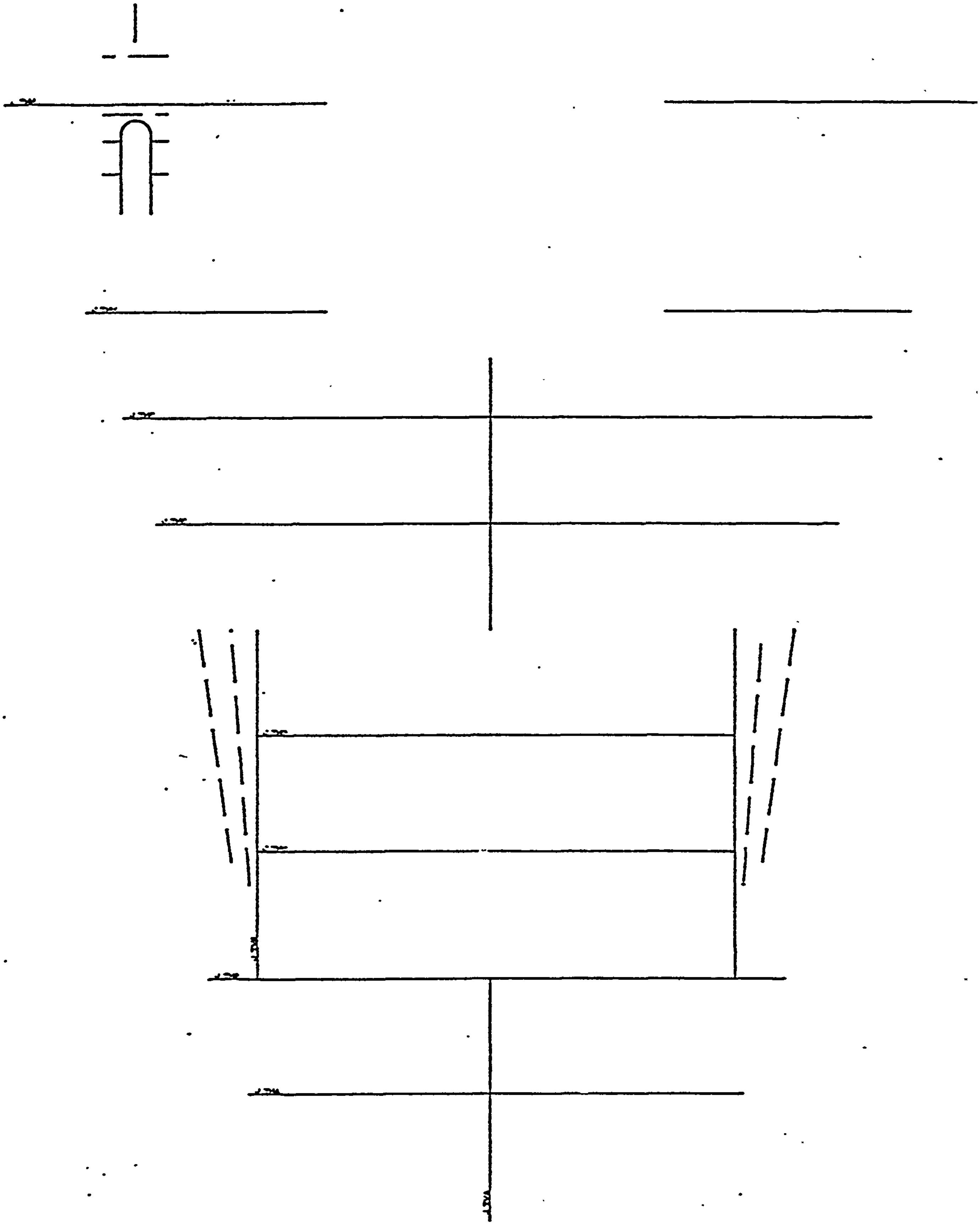
```
                         X        14     1823                                      1290100160
                         P        11                                               1290100164
TRE     STIFLAPCSNPE                                       ST10                    1290100168
NTR                                                                                1290100172
ANU                      P        21                                               1290100176
INE                      X        13     1821                                      1290100180
                         X        14     18 8                                      1290100184
TRE     STIFLAPCSNPE                                       S TQ                    1290100188
-------------------------------------------------------------------
  ADD SEAMS
-------------------------------------------------------------------
DDP                          911                                    51             1290100200
                         P        51                                52             1290100204
                         P        52                  911           53             1290100208
                         P        53                  9             54             1290100212
                         P        54                  8 2           55             1290100216
                         P        55                  8 3           56             1290100220
                         P        56                  8 3           57             1290100224
                         P        57                  8 3           58             1290100228
                         P        58                  8 3           59             1290100232
                         P        59                  8             60             1290100236
NTR                                                                                1290100240
HEL                 P+     M                                                       1290100244
OOP                     N          1 N       61 N       70                         1290100248
TNO                      L         1                                               1290100252
LPE2                    XX    * -10                                              * 1290100256
NDL                      N         1                                               1290100260
TRE     NOCT                                                                       1290100264
EAM                      P        51             P      61                         1290100268
                          J HA               11         11                         1290100272
EAM                      P        52             P      62                         1290100276
                          J HB               11         10                         1290100280
EAM                      P        53             X      63     1711                1290100284
                          J HC               10         10                         1290100288
EAM                      P        54             X      64     1711                1290100292
                          J HD               10          9                         1290100300
EAM                      P        56             P      66                         1290100304
                          J HE      D        17          8                         1290100308
EAM                      P        57             P      67                         1290100312
                          J HF                8          7                         1290100316
EAM                      X        58     12 8    P      68                         1290100320
                         T HG                 7          6                         1290100324
EAM                      X        60     12 8    P      70                         1290100328
                          T HH                5          5                         1290100332
DDP                       D 67F     P ORG                        6  71             1290100336
EAM                      P        71             X      55       6                 1290100340
                          J VB    P           8          8                         1290100344
EAM                      X        52        6       0            6                 1290100348
                          J VA    P          11         11                         1290100352
EAM                      X        55     1711    X      52     1711                1290100356
                          T VC               10         10                         1290100360
NPE                                                                                1290100364
```



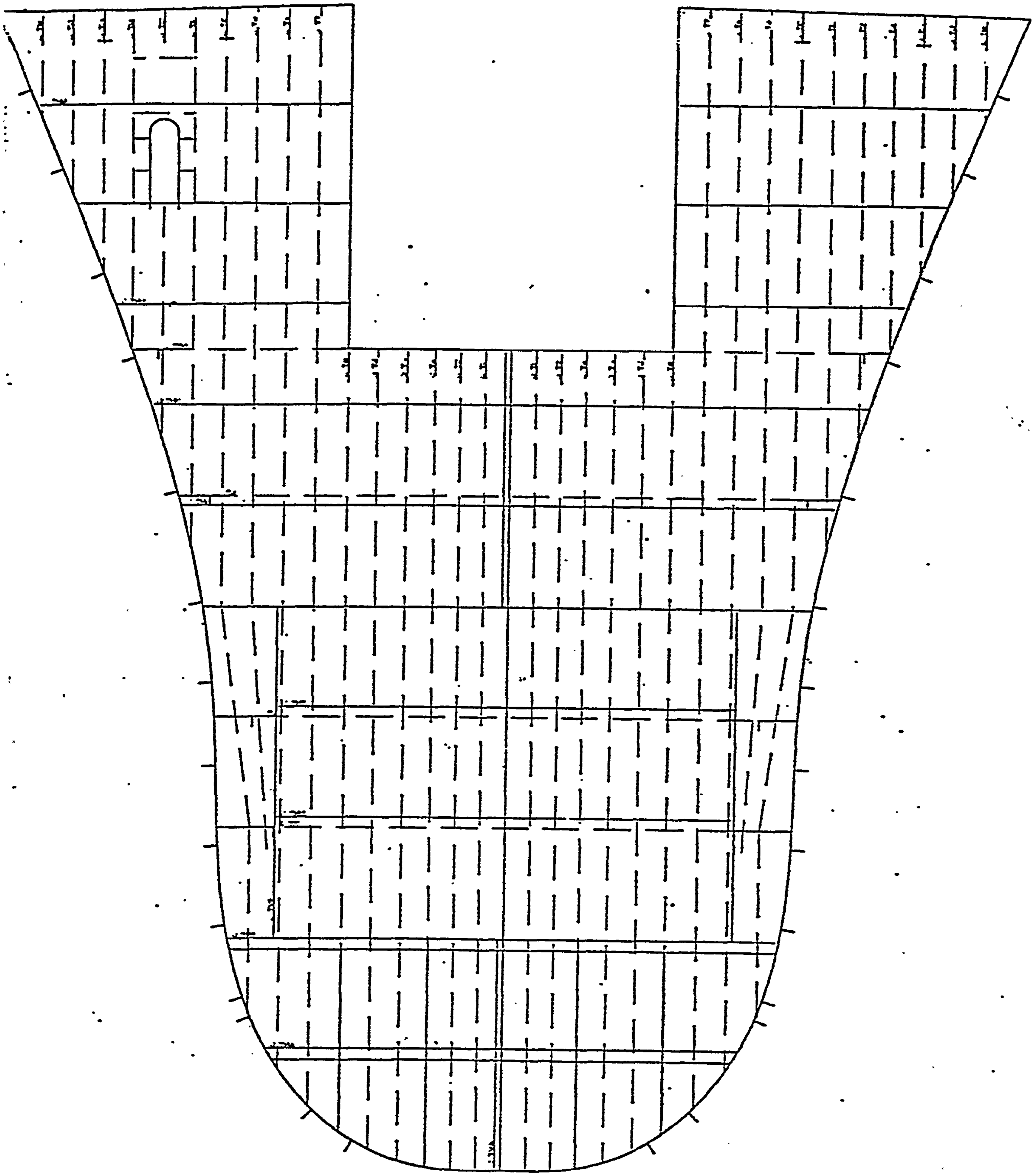
EXAMPLE 2: Bulkhead 31
Drawing of major structure after 'HULLOAD' only



Example 2: Bulkhead 31
Drawing of loaded details after 'HTLLOAD'



Example 2: Bulkhead 31
Details programmed in 'DEMO'



Example 2: Bulkhead 31
Final drawing after detailing by 'DEMO'

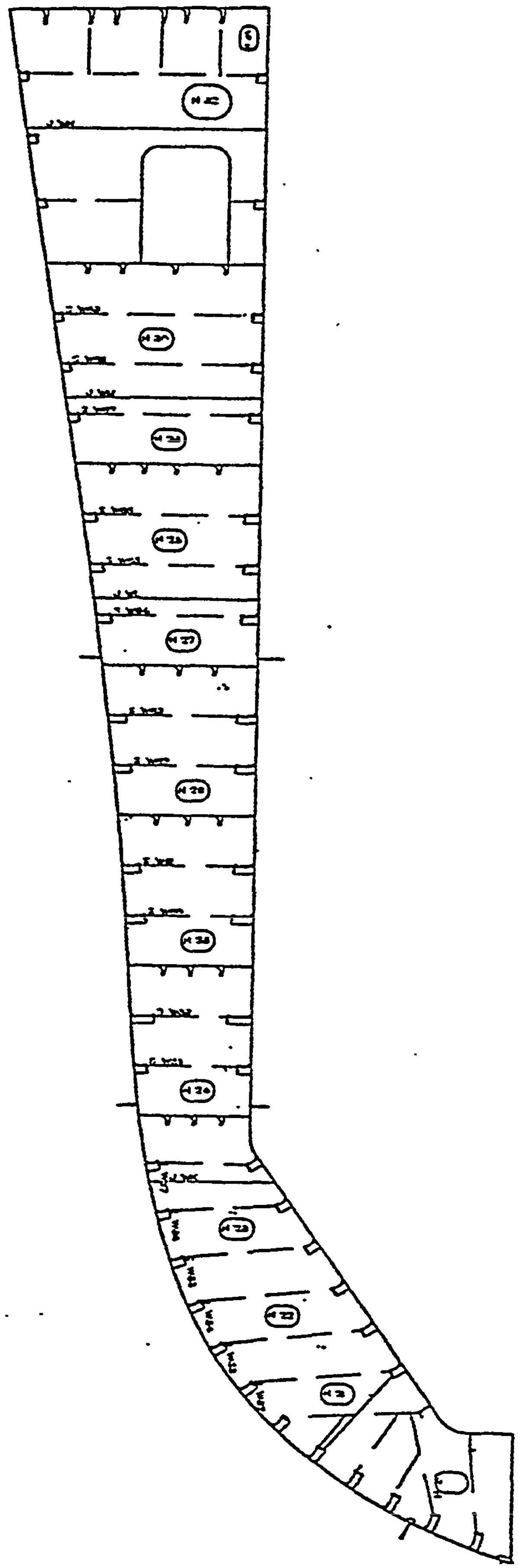
****** EXAMPLE 3 : INPUT DECK FOR DETAILING OF WEBFRAMES 52 THROUGH 50

```
-----------------------------------------------------------------------

*JOB LNG DEMO          N     9003                                             12900301
INPS                   N     9003                                             12900301
-------------------------------------------------------------------------
       AUTOMATIC DRAWING FROM THE DATA BASE
-------------------------------------------------------------------------
IRSV              FWD   F 52.      F  50.                                     12900301
LIMT                    M          S 14      D MDK      P END                 12900301
OPTN     SCAL     CUTS             V  48.                                     12900301
-------------------------------------------------------------------------
       START DETAILING
       COMMAND LAPC - DEFINING STANDARD END CONNECTIONS
-------------------------------------------------------------------------
DEFH                       23         15                       1              12900301
LAPC                        3          1 8        1 8                         12900301
-------------------------------------------------------------------------
       DEFINE SEAMS
-------------------------------------------------------------------------
ADDP                    D 28F      P END        -4             1              12900301
                        D 67F      P END        -8             2              12900301
                        D 2ND      P END        -8             3              12900301
                        D 2ND      P END         8 0 9     3   4              12900301
CNTR     CALC                                                                 12900301
SHEL              P+                                                          12900301
SLPE2                   Y D TT     P END                                 520  12900301
    2                 XX        1                                        5 1  12900301
    2                 XX        2                                        5 2  12900301
    2                 XX        3                                        5 3  12900301
    2                 XX        4                                        5 4  12900301
LINK     NEW                                                                  12900301
LBHD              P+    L LB6                                                 12900301
SLPE2                 XX        1                                        511  12900301
    2                 XX        2                                        512  12900301
    2                 XX        3                                        513  12900301
    2                 XX        4                                        514  12900302
CTRE     NOCT                                                                 12900302
SEAM                   P        1            P       11                       12900302
                        J WK             10          12                       12900302
                       P        2            P       12                       12900302
                        J WL              9           9                       12900302
                       P        3            P       13                       12900302
                        J WM              9           9                       12900302
                       P        4            P       14                       12900302
                        J WN              9           9                       12900302
                        M          SS 23       L LB6     SS 18                12900302
                        J WJ           1             10                       12900302
```

```
      DEFINE HOLES
-----------------------------------------------------------------------------
ADDP                 P        20                3 6               20    12900302
HOLD                 P        20           A    0.        H 20     1    12900302
MIDN                  L LB6                                             12900302
SPLT                 IS 17                 M              IS 24   18    12900302
                     IS 18                 M              IS 25   19    12900302
                     P        18           P       19             21    12900302
                     IS U                  M              IS 26   18    12900302
                     IS 20                 M              IS 27   19    12900302
                     P        18           P       19             22    12900302
                     IS 21                 M              IS 28   18    12900302
                     IS 29                 M              IS 29   19    12900302
                     P        18           P       19             23    12900302
                      D 28F                M               D 28F  18    12900303
                     IS 32                 M              IS 32   19    12900303
                     P        18           P       19             24    12900303
                      D 37F                M               D 37F  18    12900303
                     IS 35                 M              IS 35   19    12900303
                     P        18           P       19             25    12900303
                      D 46F                M               D 46F  18    12900303
                     IS 38                 M              IS 38   19    12900303
                     P        18           P       19             26    12900303
                      D 55F                M               D 55F  18    12900303
                     IS 41                 M              IS 41   19    12900303
                     P        18           P       19             27    12900303
                     IS 42                 M              IS 42   18    12900303
                     IS 43                 M              IS 43   19    12900303
                     P        18           P       19             28    12900303
                      S 67F                M               D 67F  18    12900303
                     IS 45                 M              IS 45   19    12900303
                     P        18           P       19             29    12900303
                     IS 46                 M              IS JL   18    12900303
                     IS 47                 M              IS 47   19    12900303
                     P        18           P       19             30    12900303
LOOP                 N         1 N      21 N       30                   12900303
PTNO                  L        1                                        12900303
HOLD                 P    *                A   90.        HLOOP 1  1    12900303
ENDL                 N         1                                        12900304
ADDP                  L LB6       S 50          2 1          3 4 8 32   12900304
HOLD                 P        32           A . 909        H 32          12900304
                         33          24                                 12900304
                           6            12                              12900304
ADDP                  D MDK    . L LB6         -22            13  33    12900304
HOLD                 P    .   33                          H 33          12900304
                         18          12                                 12900304
ADDP                  L LB6       D 2ND                      11015 40   12900304
                     P        40                             5   18 44  12900304
                     P        40                7    9            41    12900304
```

```
                                P       44                      7    9                 43       12900304
CNTR                                                                                            12900304
CORN                            P       40                                                      12900304
                                P       41                      12 9                            12900304
                                P       42                      12 9                            12900304
                                P       43                                                      12900304
CTRE      HOLD                         6               9                 H 31                   12900304
-----------------------------------------------------------------------------------------
        DEFINE STIFFENERS
-----------------------------------------------------------------------------------------
ADDP                             M           IS 24                                     49       12900304
VECT                             L LB6       IS 17       P          49           6     50       12900304
LINT                            P       50               P          49                          12900304
                                 M           IS 22       A*                            51       12900304
                                 M           IS 20       P          50                          12900304
                                 M           IS 21       A*                            52       12900304
                                P       49               P          50                          12900305
                                 M           IS 23       A*                            53       12900305
PNCH3                            M           IS 20       P          50                          12900305
STIF   501NSIDLAPCSNPE                                             1 8     S 101                12900305
PNCH3                            M           IS 21       P          52                          12900305
STIF   501NSIDLAPDSNPE                                             1 8     S 102                12900305
PNCH3                            M           IS 22       P          51                          12900305
STIF   501NSIDLAPCSNPE                                             1 8     S 103                12900305
PNCH3                            M           IS 23       P          53                          12900305
STIF   501NSIDLAPCSNPE                                             1 8     S 104                12900305
LINT                             L LB6        S 51       M                 S 51                 12900305
                                 D MDK        S 23       A*                            60       12900305
                                 L LB6        S 51       M                 S 51                 12900305
                                 D MDK        S 23B      A*                            61       12900305
                                 L LB6        S 51       M                 S 51                 12900305
                                 D MDK        S 24A      A*                            62       12900305
                                 L LB6        S 51       M                 S 51                 12900305
                                 D MDK        S 25       A*                            63       12900305
LAPC                                   2   S           7                                        12900305
PNCH2                            D MDK       IS 23       P          60                          12900305
STIF   502NSIDLAPCSNPE                                              7      S W73                12900305
PNCH3                            D MDK       IS 23B      P          61                          12900305
STIF   502NSIDLAPCSNPE                                              7      S W74                12900305
PNCH3                            D MDK       IS 24A      P          62                          12900305
STIF   502NSIDLAPCSNPE                                              7      S W75                12900306
PNCH3                            D MDK       IS 25       P          62                          12900306
STIF   502NSIDLAPCSNPE                                              7      S W 76               12900306
ADDP                             L LB6        S 49                                11015 64      12900306
                                 M            S 49                                      65      12900306
PNCH3                            L LB6       IS 49       P          64                          12900306
STIF   503MSIDLAPCSNPE                                              7      S 105                12900306
PNCH3                            M           IS 49       X          65 Y            44          12900306
STIF   503NSIDLAPCSNPE                                              7      S W70                12900306
```

```
-----------------------------------------------------------------------
:      . LOAD FRAME 52
-----------------------------------------------------------------------
LOAD                                F 52                                  129003063
-----------------------------------------------------------------------
      REDEFINE STIFFENERS FOR FRAME 51 AND 50
-----------------------------------------------------------------------
HOLD                  P       29          A   90.      H 29     1         129003064
                      P       30          A   90.      H 30     1         129003064
LINT                   L LB6     S 51     M            S 51               129003064
                       D MDK    IS 23A    A*                    66        129003065
                       L LB6     S 51     M            S 51               129003065
                       D MDK    IS 24B    A*                    67        129003066
                       L LB6     S 51     M            S 51               129003066
                       D MDK     IS 24    DD 2ND       S 2B     68        129003066
                       L LB6     S 50     M            S 50               129003067
                       D MDK    IS 24      D 2ND       S 2B     69        129003067
                       L LB6     S 49     M            S 49               129003068
                       D MDK    IS 24      D 2ND       S 2B     70        129003068
                       D 2ND    IS 2A      D 67F       S 2A               129003068
                       L LB6     S 47     M            S 47     71        129003069
                       D 2ND    IS 2A      D 67F       F 2A               129003070
                       L LB6     S 46     M            S 46     72        129003070
                       D 2ND    IS 2A      D 67F       S 2A               129003070
                       L LB6     S 45     M            S 45     73        129003071
PNCH3                  D MDK    IS 23A    P   66                          129003071
STIF  502NSIDLAPCSNPE                              7   S W77              129003072
PNCH3                  D MDK    IS 24B    P   67                          129003072
STIF  502NSIDLAPCSNPE                              7   S W78              129003072
PNCH3                  D MDK    IS 24     P   68                          129003073
STIF  502NSIDLAPCSNPE                              7   S W79              129003073
ONCH3                 P       68          P        69                     129003074
STIF  502NSIDSNPESNPE                    7         7   S W80              129003074
ONCH3                 P       69          P        70                     129003074
STIF  502NSIDSNPESNPE                    7         7   S W81              129003075
PNCH                  P       70           D 2ND       S 2B               129003075
STIF  502NSIDSNPESNPE                    7         7   S W82              129003076
PNCH3                  D 2ND    IS 2A     P        71                     129003076
STIF  502NSIDLAPCSNPE                              7   S W83              129003076
PNCH3                  P      71          P        72                     129003077
STIF  502NSIDSNPESNEP                    7         7   S W84              129003077
PNCH3                 P       72          P        73                     129003078
STIF  502NSIDSNPESNPE                    7         7   S W85              129003078
PNCH3                 P       73           D 67F       S 2A               129003078
STIF  502NSID SNPESNPE                   7         7   S W86              129003079
-----------------------------------------------------------------------
      LOAD FRAMES 51 AND 50
-----------------------------------------------------------------------
LOAD                                F 51.     F 50.       1.              129003080
INPE                                                                      129003080
```



Example 3 : Window of Webframe 52 after detailing by 'DEMO'

# APPENDIX 1

## HULLOAD INPUT REQUIRED TO LOAD STIFFENERS ‘TO DATA BASE

****** EXAMPLE 1 : INPUT DECK TO DEFINE AND LOAD
VERTICAL STIFFENERS ON BULKHEAD 31.

```
*JOB LNG HULDDISK        N     3001                                              17300100
INPS          16TH       N     3001                                              17300100
TRAC TBHD                 T 31.                                                  17300100
TOLR                           100          100                                  17300100
STIF NAME                 S T1        S T2        S T3        S T4               17300100
                          S T5        S T6        S T7        S T8               17300100
                          S T9        S T10       S T11       S T12              17300100
                          S T13       S T14       S T15       S T16              17300100
                          S T17       S T18       S T19       S T20              17300100
REFR                      L CLB     Y P ORG                                      17300100
CNCT2EQSP                 M         Y     20500   D 67F                          17300100
REPT                      M         Y S 1         D 67F                          17300100
CNCT2                     M         Y S 7         D 67F                          17300100
    2EQSP                 M         Y    -20500   D 67F                          17300100
REFR                      M         Y S 7                                        17300100
CNCT2EQSP                 M         Y     20500   D MDK                          17300100
REPT                      M                       D MDK     Y S 10               17300100
                          M                       D MDK     Y S 14               17300100
                          D MDK     Y P END                                      17300100
INPE                                                                             17300199
```

****** EXAMPLE 2 : INPUT DECK TO DEFINE AND LOAD
VERTICAL STIFFENERS ON TRANSVERSE FLOORS
AT FRAMES 46 THROUGH 52.

```
---------------------------------------------------------------------
*JOB LNG HULDDISK      N     3002                                            17300200(
INPS          16TH     N     3002                                            17300200(
LOOP                   N        1 N  460000 N  520000 N   10000              17300200(
TRAC TBHD               T R    1                                             17300200(
STIF NAME               S W1       S W2       S W3       S W4                17300200:
                        S W5       S W6       S W7       S W8                17300200'
                        S W9       S W10                                     17300200;
CNCT                    M          S 2        D TT       S 2                 17300200;
REPT                    M          S 14       D TT       S 14                17300200;
ENDL                   N        1                                            17300200:
INPE                                                                         17300299'
---------------------------------------------------------------------
```

****** EXAMPLE 3 : INPUT DECK TO DEFINE AND LOAD STIFFENERS ON WEBFRAMES 46, 50 AND 52.

```
*JOB LNG HULDDISK        N    3003                                         17300399
INPS          16TH       N    3003                                         17300300
LOOP                     N       1 N  460000 N  520000 N   20000           17300300
IFEQ                     L       1 N  480000 N      99                     17300300
TRAC TBHD                  T R  1                                          17300301
STIF NAME                  S W50      S W51     S W52     S W53            17300301
                           S W54      S W55     S W56     S W57            17300301
                           S W58      S W59     S W60     S W61            17300302
                           S W62      S W63     S W64     S W65            17300302
                           S W66      S W67     S W68     S W69            17300302
                           S W70      S W71     S W72     S W73            17300303
CNCT                       M          S 19      D TT      S 16             17300303
                           L LB6      S 17      M         S 24             17300304
REPT                       L LB6      S 51      M         S 51             17300304
NTRY                     N      99                                         17300304
ENDL                     N       1                                         17300305
INPE                                                                       17300399
```

EXAMPLE OF PART CODING

AFTER USE OF DETAIL ENGINEERING MODULE

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456

INPUT UPDATING            DATE  12/10/75     TIME  18/31/54      RUN NO.    2
JOB  LNG        PROG. PART      INPUT ID. 6515         REV. NO.   4       PAGE

INPS                  N.    6515                   375                10651501
RMKS  EXAMPLE OF PART                                                 10651501
      CODING AFTER                                                    10651501
      USE OF DETAIL                                                   10651501
      ENGINEERING MOD                                                 10651501
TRSV                  F 52.                                           10651501
DPWG  11-03-03                                                        10651501
STRT                  M          L L15                                10651501
LINE2                    8 6                                   1      10651501
PART                                                                  10651501
OUTP                                                                  10651501
CNTR  DOWNOUTP                                                        10651501
DECK             P+    D TT                                           10651501
LINK     RND.            - 24                                         10651501
LEND             P+    L L86                                          10651501
LINK     INT                                                          10651501
DECK             P+    D MDK                                          10651501
LINK     INT                                                          10651501
SHEL             P-    M                                              10651501
CTRE                                                                  10651501
MIDN                   D TT                                           10651501
DBCT             SPL   L L15                                          10651502
MIDN                   L L86                                          10651502
RNGE                   P ORG        END                               10651502
RATH2        --      X P END            3                             10651502
MIDN                   D MDK.                                         10651502
RNGE                   S 23       P END                               10651502
RATH2                Y P END            3                             10651502
MIDN                   M                                              10651502
RNGE                   D MDK      J  D                                10651502
DBCT             SPL   L L15                                          10651502
LINE                   P        1                                     10651502
MIDN                   M                                              10651502
LOOP2                DN         1  D 28F       D 2ND                  10651502
CNTR    CUTSONLY                                                      10651502
DECK             P+    DLOOP 1                                        10651502
CTRE                                                                  10651502
MIDN                   DLOOP 1                                        10651502
RNGE                   L L86      P END                               10651502
CUTE                                                                  10651502
ENDL                  N         1.                                    10651502
DEHL                                                                  10651502
DEMK                                                                  10651502
ENDP    PSEETAPE                                                      10651502
DELT                   M          S-14      M         D MDK     99    10651503
MOVE2                           0 Y        99                         10651503
PART DET.6-A PPC.194                                                  10651503
POEF                 R- J  WJ                                         10651503
PCID   PC.194*         M          S 15     A  0.          2 0         10651503
ENDP    STOPTAPE               1 0                                    10651503
MOVE2                          3 0                                    10651503
PART DET.6-A  PC.183                                                  10651503
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456

INPUT UPDATING           DATE  12/10/75     TIME  18/21/54     RUN NO.    2
JOB  LNG       PROG. PART       INPUT ID. 6515        REV. NO.    4       PAGE

PDEF                      J WJ                J VK                       10651503
PCID    PC.183*           M          IS 21    A -90           2 0        10651503
ENDP      STORTAPE               10                                      10651503
MOVE2                           3 0                                      10651503
PART DET.6-A   PC.182                                                    10651503
PDEF                    R J WK                D 28F                      10651503
PCID    PC.182*           M          IS 30    A -90.          2 0        10651503
ENDP      STORTAPE               12                                      10651503
MOVE2                           3 0                                      10651503
PART DET.6-A   PC.179                                                    10651503
PDEF                    R D 28F               D 37F                      10651504
PCID    PC.179*           M          IS 33    A -90.          2 0        10651504
ENDP      STORTAPE               13                                      10651504
MOVE2                           3 0                                      10651504
PART DET.6-A   PC.172                                                    10651504
PDEF                    R D 37F               D 46F                      10651504
PCID    PC.172*           M          IS 36    A -90.          2 0        10651504
ENDP      STORTAPE                9                                      10651504
MOVE2                           3 0                                      10651504
PART DET.6-A   PC.171                                                    10651504
PDEF                    R D 46F               D 55F                      10651504
PCID    PC.171*           M          IS 39    A -90           2 0        10651504
ENDP      STORTAPE                9                                      10651504
MOVE2                           3 0                                      10651504
PART DET.6-A   PC.281                                                    10651504
PDEF                    R D 55F               J WL                       10651504
PCID    PC.281*           M          IS 41    A -90.          2 0        10651504
ENDP      STORTAPE                9                                      10651504
MOVE2                           3 0                                      10651505
PART DET.6-A   PC.166                                                    10651505
PDEF                    R J WL                D 67F                      10651505
PCID    PC.166*           M          IS 43    A -90.          2 0        10651505
ENDP      STORTAPE                9                                      10651505
MOVE2                           3 0                                      10651505
PART DET.6-A   PC.164                                                    10651505
PDEF                    R D 67F               J WM                       10651505
PCID    PC.164*           M          IS 45    A -90.          2 0        10651505
ENDP      STORTAPE                9                                      10651505
MOVE2                           3 0                                      10651505
PART DET.6-A   PC.163                                                    10651505
PDEF                    R J WM                D 2ND                      10651505
PCID    PC.163*           M          IS 47    A -90.          2 0        10651505
ENDP      STORTAPE                9                                      10651505
MOVE2                           3 0                                      10651505
PART DET.6-A   PC.159                                                    10651505
PDEF                    R D 2ND               J WN                       10651506
PCID    PC.159*           M          IS 49    A -90.          2 0        10651506
ENDP      STORTAPE                9                                      10651506
MOVE2                           3 0                                      10651506
PART DET.6-A   PC.155                                                    10651506
PDEF                    R J WN                                           10651506
ADDP                      D MDK      L LB6          -22 0     +13 0 90   10651506
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456
```

```
 1         2         3         4         5         6         7
34567890123456789012345678901234567890123456789012345678901234567890123456789012345678
INPUT UPDATING              DATE  12/10/75    TIME  18/31/54     RUN NO.    2
IDS  LNG      1 PROG. PART      INPUT ID. 6515        REV. NO.   4          PAGE    3
HOLE              P       90              A   0.                        106515063
                       18.0       12 0                                  106515064
  ID   PC.155=         M           IS 51       A  -40.          2 0      106515064
ENDP     STORTAPE              9                            0648   106515064
LNPE                                                                    106515999
 1         2         3         4         5         6         7
1.34567890123456789012345678901234567890123456789012345678901234567890123456789012345678

         SEVERITY = 0     INPUT IS STORED WITH REV. =   5

                          INPUT IS EXECUTABLE
```

APPENDIX K

LSCO FINAL REPORT - SUB-TASK 2.1 COMPUTER-AIDED DESIGN SYSTEMS

FINAL REPORT--SUB-TASK 2.1

COMPUTER AIDED DESIGN SYSTEMS

CONTENTS

Sub-Task 2.1 Final Report
Computer-Aided Design

# I. Summary

Sub-task 2.1 began in November 1978 with a meeting of IHI and Levingston representatives. This first meeting was held primarily to determine the method of approach which would provide accurate descriptions of both systems from which detailed comparisons could be made. From such comparisons, deficiencies in the Levingston system could be isolated and recommendations for change could be developed.

Thus, IHI began its investigation of the Levingston system which continued through February of 1979. The result of this investigation was detai1ed report prepared by Masumi Hatake of IHI. This report consists of three sections: 1. Examine and Study the SPADES System; 2. IHI System; and 3. Comparison of the Capabilities between Levingston's SPADES System and IHI System. Each section is described as follows:

The purpose of Section 1 was to determine if full utilization and benefit is being realized from the use of the system by Levingston. All available SPADES modules were studied (even though some have not been installed for use at Levi ngs ton). (Appendix 1, P. 1.3-1).

Section 2, the IHI System, adequately describes the characteristics and functions of each IHI system (module). (Appendix 1, p. 2.1-l through 2.1-9). The relationships between the systems is shown in a flow chart. (Appendix 1; p-2-0-3).

Section 3, which compares the capabilities of the IHI system and the SPADES system, concludes that the capabilities of the two are almost equal. (Appendix 1, p.3.1.2). In addition analysis is provided on the adaptability of the IHI software to the SPADES system. (Appendix 1, p.312-1).

A meeting was held for the presentation of the report and to allow for explanations and discussions. (Technical memoranda-Appendix 12).

I. Continued

In conjunction with the above report, IHI also delivered to Levingston descriptions of the IHI computer design modules. The descriptions were used in the establishment of a detailed comparison table. This table is the basis for Levingston's report entitled "Study and Comparison of SPADES vs. IHI System". (Appendix 2). The comparison table was established according to the specific application of each module. The report consists mainly of a detailed explanation of the corn-parison table followed by conclusions.

A detailed deficiency analysis and trade-off study was not prepared due to the fact that IHI and Levingston both concluded that the SPADES system is adequate for Levingston's present and future needs. A memorandum to that effect was prepared and is attached as Appendix 3.

## II. Comparison Analysis Conclusions

(RE: Appendix 2)

In general, the IHI N/C system and the SPADES N/C system are both very good. Whereas, IHI utilizes its system to its maximum capabilities, Levingston's use of SPADES is not so comprehensive due to lack of implementation and facilities. For example, the absence of an N/C drafting machine is partly the reason for not perfoming lines fairing in-plant, and for not installing the new DEMO-module of SPADES. The functions of HULLCAL, another SPADES module not in use at Levingston, are duplicated through the use of SHCP which is obtained from another source. HULLCAL directly references the data base but needs some improvements in capabilities, whereas SHCP requires a manual loading of data but adequately performs the necessary functions.

In each case, there is some justification for non-use of certain SPADES modules. Benefits of the additional machine capabilities from the installtion of an N/C drafting machine may very well be offset by costly additional personnel requirements. Contracting lines fairing from outside sources may be less expensive than performing the same work in-plant, and definitely draws from the experience of the contractor in fairing many different hull types and shapes.

SPADES may have the advantage over the IHI system when comparing the modules that actually duplicate the old style lofting and template making methods due to easier input coding and full utilization of the data base set up with the Fairing and Hulload modules. (All SPADES modules access the data base, whereas some of the IHI modules are stand-alone systems.)

Implementation of the IHI system at Levingston is not necessaryz- The SPADES system currently available to Levingston is more than adequate for present and future needs.

The capability of SPADES is considered to be almost equal to the IHI system. Full configuration of the SPADES system covers much the same area as the IHI system, except for structural analysis and vibrational analysis (which are obtained by Levingston from other sources).

## III. Production Improvement Suggestions - IHI

IHI strongly recommends that Levingston make full use of the SPADES system. (p.1.3-6, Appendix). Specifically, it is recommended that Fairing can be performed in-plant as opposed to the present practice of contracting this work, thus creating a time delay. Fairing the hull in-plant would enable a faster start on all design work. (p.1.3-5, Appenix 1).

In order to directly utilize the Fairing module, (as well as some other modules not currently used), IHI recommends the installation of a large drafting machine. (p.1.3-7, Appendix 1) . This will also help eliminate duplicated work between the Mold Loft and Engineering. (p.1.3-5, Appendix 1). The drawings from the drafting machine can be used as the base drawings from which more detailed design can be performed as well as checking the drawing for input. (p.1.3-6, Appendix 1)

The DEMO module of SPADES is also facilitated through the installation of an N/C drafting machine. (p. 1.3-7, Appendix 1). According to the IHI report DEMO will provide the following:

*Fast issue of working drawings
*Easy and quick follow-up to design change
*Exclusion of duplicated work
*Manpower savings

As part of Sub-task 2.2, a justification analysis will examine these opinions in detail as to their validity.

## VI. Change Analysis Conclusions

It was finally concluded by IHI and Levingston that SPADES offers enough depth, flexibility and future growth potential so that no changes involving the IHI system will be necessary. For this reason a brief explanation of this conclusion was submitted in the form of a memorandum in lieu of a formal change analysis document. (See Appendix 3.)

Some recommendations have been received to install additional N/C hardware. In relation to IHI's recommendations, this activity is directly related to Sub-task 2.2-Numerical Control Steel Fabrication. Upon actual installation of recommended equipment, expansion of Levingston's use of SPADES is to be expected. Monitoring and reporting of the installation of such hardware will be reported in the sub-task 2.2 Final Report. As Levingston's use of SPADES increases, reports to that effect can be submitted in addendum to the sub-task 2.1 final report.

## V• Recommendations By IHI

IHI recommends, through Mr. Hatake's report, that Levingston should attempt to make full use of the SPADES system. (p.l.3-6 Appendix 1).

By installing a large N/C directed drafting machine, it would become possible to install two very helpful SPADES modules, Fairing and DEMO. Fairing is now done by Cali and Associates which creates additional expense and time de1ays. (p.1.3-5, Appendix 1). DEMO would contribute significantly to 1.) fast issue of working drawings, 2.) easy and quick follow-up to design change, 3.) exclusion of duplicated work (p.l.3-5, Appendix A) and 4.) manpower savings (in Engineering office p.l.3-6, Appendix A). (p.1.3-7, Appendix A).

As stated in Section III of this report, the benefits of the above recommendations will be weighed as part of sub-task 2.2.

VI. References (Appendices)

1. Study Of SPADES and LSCo Utilization - IHI
2. Study and Comparison of SPADES vs. IHI System - LSCo
3. Memorandum: Deficiency Analysis and Trade-Off Studies - LSCo
4. Brief Explanation of IHICS
5. IHICS - Input/Output Examples
6. SPECS
7. SPECS - Actual OUtput Example
8. Plate Users Manual and Output Sample
9. SHELL
10. LODACS
11. SPAC
12. Technical Memorandum: Meeting--1HI 2.1 Final Report (IHI)

APPENDIX L

LSCO FINAL REPORT - SUB-TASK 2.2 NUMERICAL CONTROL STEEL FABRICATION

FINAL REPORT--SUB-TASK 2-2

NUMERICAL CONTROL STEEL FABRICATION

CONTENTS

# SUB-TASK 2.2 FINAL REPORT

## 1. SUMMARY

Work began on Sub-task 2.2 of the Technology Transfer Program in November 1978 when Levingston and IHI represenatives met to discuss scope, approach and methods. As in Sub-task 2.1, the first step was to study and describe the IHI and Levingston system in order to quantify the present use of current system as compared to its potential capabilities. IHI's M. Hatake began a thorough study and investigation of the Levingston N/C system. At the same time, a documentation of the IHI N/C system was prepared. In March of 1979, IHI delivered a detailed report of their findings concerning Levingston's N/C system as well as a general description of the IHI N/C system. As the information was presented, iterms of comparison and contrast were identified.

A meeting was held for the formal presentation of this IHI report and to facilitate a question and answer session. Representatives of the Mold Loft and Engineering were afforded the opportunity to get a cl ear explanation of any item in the report they considered unclear or erroneous.

Levingston began a complete study and comparison of the two systems. The result of this report was a general comparison of the philosphies of N/C steel fabrication. A brief description of equipment used and the flow of events involved beginning with contract signing through actual fabrication was to be the basis of the resulting report, Consideration of IHI recommendations also became a major part of the task.

Deficiencies, or area; in need of improvements in methods, facilities or equipment, were identified in Levingston's deficiency analysis and trade-off studies report. Only the items considered by Levingston to be deficient may be so because of restrictions not prevalent in the IHI yards. However, for the most part IHI's recommendations were followed up with justification analyses which helped in -the decision making of whether or not to imp1ement change recommendations.

## II. COMPARISON ANALYSIS CONCLUSIONS

### A. Philosophies on N/C Steel Fabrication

Two different philosophies of N/C steel fabrication have developed at IHI and Levingston. These differences are perhaps rooted in differing conditions which affect the shipyards. The abundance of skilled manpower, the close relationships between yards and subcontractors, industry-wide standards and highly developed facilities, among other reasons, have all contributed to the present policies and methods utilized by IHI. At Levingston, in many cases, conditions are opposite of those at IHI. In turn, these conditions have had impact on Levingston's methods and policies regarding N/C steel fabrication.

In Japan, IHI is able to recruit mold loft and layout personnel from an abundant market of job seekers. They can also be relatively certain that once hired and trained, these employees 'Wi11 remain at IHI until retirement, except in unusual circumstances.

At Levingston, and in the U.S. shipbuilding complex as a whole, there is a shortage of skilled lofting and layout personnel.

It follows that IHI's philosophy of N/C utilization for steel fabrication may be different than at Levingston, and it is. IHI tends to process through N/C only that steel which requires high precision and repetition of shape such as web frames, innerbottom floors and curved shell plates. Flat, straight pieces are processed through the Panel Shop by a flame planer. Levingston, on the other hand, processes as much steel as possible through its N/C system, including flat and straight pieces.

At Levingston, plate marking for shape, structure locations, etc. is performed as much as possible by the N/C burning machine which is equipped with centerpunch marking heads. The necessary material marks and instructions are added manually after burning. Such marking is usually done before the plate is moved, but other pieces are burned simultaneously on other areas of the burning table.

On the other hand, IHI is equipped to perform a variety of N/C plate marking methods including zinc or plastic powder to form continuous line marks, manual marking of structure locations using steel tapes prepared from N/C generated data, and electro-photo marking .

At IHI-Aioi, a total of 25% of all plates for each Future 32 vessel was fabricated by the N/C equipment. By contrast, at Levingston almost all plates for a vessel are produced by N/C equipemnt.

II. COMPARISON ANALYSIS CONCLUSIONS, CONTINUED.

B. Equipment And Personnel

| Levingston-Orange | IHI-Aioi |
|---|---|
| *Punch marking on same machine | *Line marking-zinc powder burning |
| *13 Loft personnel | *50 Loft personnel |
| *1500 to 1800 tons/month | *6000 to 8000 tons/month |
| One (1) Burning Machine | Three (3) Burning Machines |
| *Direct Control | Tape Control |
| *SPADES | *IHI System |

C. Levingston Deficiencies Identified By IHI.

1. No alternate method of automatic burning for times when N/C burning machine is out of service.

2. No panel shops for rapid fabrication and assembly of flat and curved panels , complete with stiffeners, using a flame planer.

3. No numerically controlled drafting system for visual checking of data base for hull parts, template making for fabrication and bending, producing drawings for use with optical tracer type burning director and possible applications for producing working drawings for Engineering .

D. Results of Deficiencies Indentification

1. As an alternative to cutting flat straight panels on the N/C burning machine, an optical 1:1 burner director has been installed to direct automatic burning machine when direct numerical control system is not in operation.

2. Work has begun or setting up a panel shop with a flame planer for flat panel fabrication.

3. A system change analysis was conducted with the result being a recommendation to imp1ement the installation of a complete N/C drafting system in the mold loft.

## III. IHI PRODUCTION IMPROVEMENT SUGGESTIONS

Since the volume of Levingston's steel fabrication is expected to increase due to the construction of the 36,000 D.W.T. dry bulk carriers, IHI has offered some suggestions such as levelling of the work load, rearrangement of shops and supporting work areas, etc.

Related to sub-task 2.2, IHI recommends consideration of an alternate method of automatic burning (to compensate for times when the present N/C burner is broken down) and installation of a large N/C drafting machine in the mold loft to facilitate a scaled plan system of lofting for template making, plate validation before burning, etc.

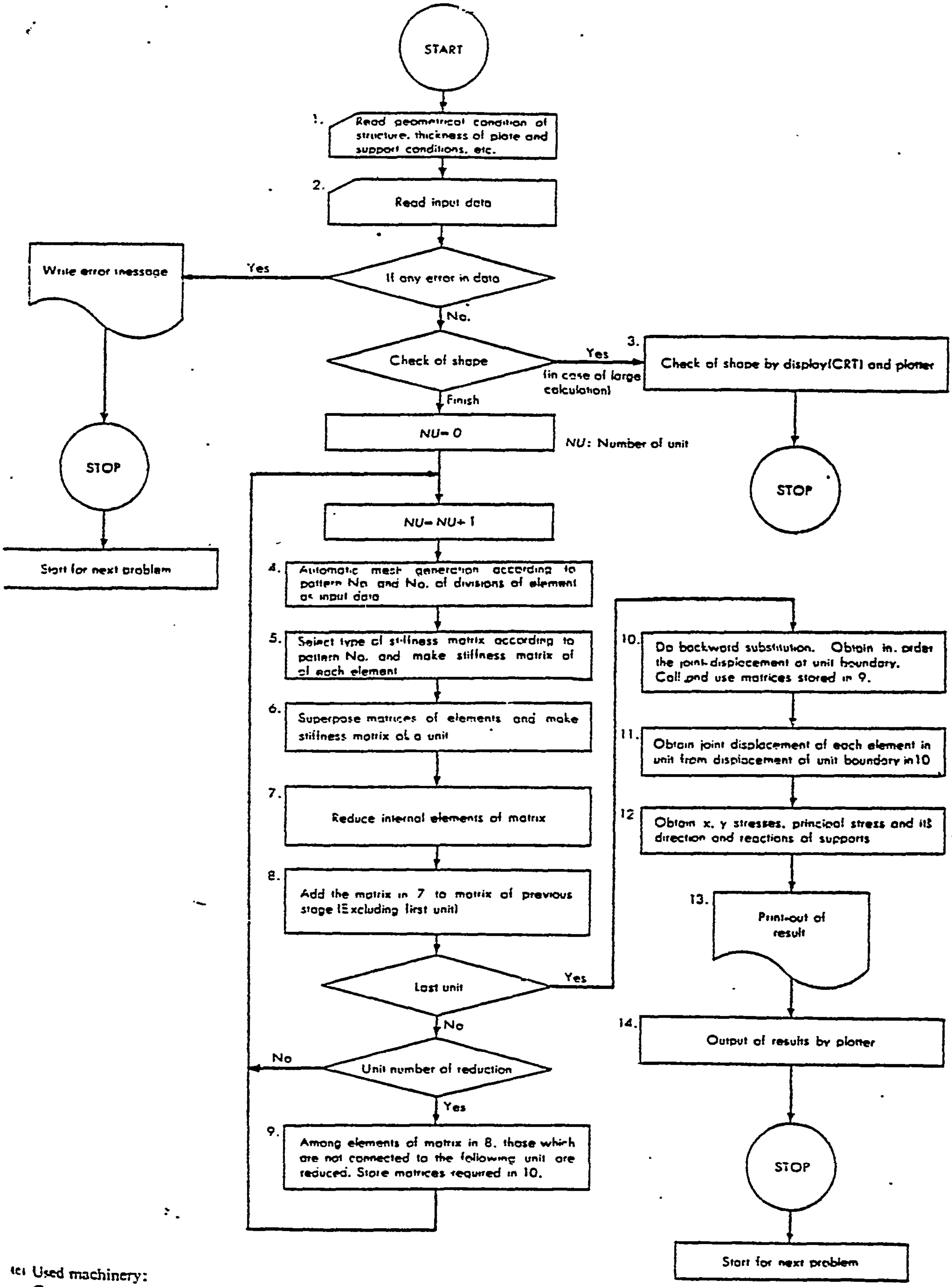
An alternate burning method of automatic burning has been installed as a result of IHI's suggestion. It is in the form of an optical 1:1 burner director. Thus, the main activity of this study is in the area of installing the N/C drafter in the mold loft.

## IV. CHANGE ANALYSIS CONCLUSIONS

In almost all of IHI's reports concerning Levingston's N/C steel fabrication, it has been suggested that a major deficiency in the mold lofting and Engineering systems is the absence of a scaled body plan system utilizing an N/C drafting machine. As a result, the attached system change analysis (reference 5) was conducted. Supporting investigative and statistical data was received from IHI (reference 6) and from Levingston's Industrial Engineering Department (reference 3). This data is the basis for determining the results of changing to an N/C drafting system in the mold loft.

In general, it is concluded that the mold loft could successfully utilize a large table N/C drafting machine with the necessary related hardware for interface with the present system. The cost vs. estimated benefit study indicates paybacks in several areas including highly accurate data bank verification, part validation before burning, template making, and providing drawings for use with Levingston's optical tracer burning director.

It may be further concluded that a monetary cost payback due to high accuracy and saved lofting manhours is the obvious benefit of using such a system. But another benefit will accrue in the form of taking more time away from the total amount of time between contract signing and delivery date. These are the kinds of savings that can benefit Levingston now as well as making the U.S.A. shipbuilding market more attractive in the near future on a worldwide basis.




(c) Used machinery:
Computer: UNIVAC-1108
Plotterr: CALCOMP
Display: ADAGE

Fig. 1 Flow chart of ZPLATE program

method item (2) is distinctively useful for structures with periodic identical patterns like ship hull structures. As to item (3), the program must be balanced with items (1) and (2) for saving labour of users. Otherwise, it is not meaningful no matter how refined the program is.

In item (5), an error message can be printed out and a check of structural geometrical data is to be done by plotter or graphic display. For item (6), automatic drawing of calculated results is done by plotter or graphic display. It is also devised to print out Calculated results in most convenient form. For item (7), it is not possible in the present stage to calculate the inverse of a stiffness matrix within the core memory of even a super large computer although it depends on the faculty of the computer. Therefore, some memory devices such as magnetic tape, disc or drum are required. Of course, it is truly useful in this case to use a super large computer with large core memory, but such a large computer is usually open to various jobs by time sharing system. This is because it is not economical to provide a large core memory only for a single small job. Therefore, we must make use of some external memory device effectively although a certain core memory is still needed.

If item (7) is solved, items (3) and (4) can be automatically worked out. If items (1) to (7) are all satisfied, it will be a very refined general purpose program finite cicment method.

## 3. Method of analyzation

ZPLATE is made to analyze by finite element method the elastic stress of plate structures subjected to static loads. Plate structures are composed of thin plates in the same plan: or of a three-dimensional combination of plates. The plate as an element of structures does not **have** stiffness against out-of-plane deformation but retains only in-plane stiffness. Therefore, stresses are assumbled to be in the plane stress equilibrium. However, the program can also analyze a plate with line membrers (created as truss elements because of no flexible stiffness). The input data **are** overall structural formulation, dimensions of members, material modulus, structural conditions of locations of supports and loads (including forced displacement) and the outputs are displacement and stress of each element and reactions of supports.

The structure to be analyzed is first divided into a remain number of units. Each unit is a **group** of **several** or several tens of elements and is functional as an element in a wide sense. Each input is associated with units and joints which are vertices of units. The unit has two types of geometry and is selected such that any structure can be easily idealized. The unit plays an important role in saving labour in preparing input data. We use "unit division method"[(1)] to solve simultaneous equations. However, the unit of the unit division has a slightly different meaning from the unit defined here, **as** will be described later (section 3.1).

3.1 Composition of program

The flow chart of the program is shown in Fig. 1 (The processes 1 to 14 are a set of subprograms specified into units of functional characteristics of operation). For the substructure method, the main program shown in Fig. 1 wiI1 be used as a subroutine as described later-

In fig. 1, the discrimination "Unit number of reduction" between processes 8 and 9 indicates that reduction is to be performed when the reduced elements of the matrix in process 9 become large by superposing several units (process 8). In other words, the reduction is not applied to each unit. This is the reason why, in the unit division method, we call one unit for these groups of units put together.

3.2 Stiffness matrix of element

Out of various stiffness matrices in plane stress problems, the following expressions can be used at present

(1) Line element

Geometric function

$$u = \alpha_1 + \alpha_2 x \quad \cdots\cdots (1)$$

(2) Triangular element (uniform stress)

Geometric functions

$$\left.\begin{aligned} u &= \alpha_1 + \alpha_2 x + \alpha_3 y \\ v &= \alpha_4 + \alpha_5 x + \alpha_6 y \end{aligned}\right\} \quad \cdots\cdots (2)$$

(3) Rectangular element[(2)]

Geometric functions

$$\left.\begin{aligned} u &= \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy \\ v &= \alpha_5 + \alpha_6 x + \alpha_7 y + \alpha_8 xy \end{aligned}\right\} \quad \cdots\cdots (3)$$

(4) Arbitraray quadrilateral and triangular element by Hybrid Method[(3)]

Assuming linear displacement along each side of the element, stresses can be put in the forms;

$$\left.\begin{aligned} \sigma_x &= \beta_1 + \beta_2 y + \beta_6 y + \beta_8 y^2 + \beta_{10} x^2 + \cdots \\ \sigma_y &= \beta_3 + \beta_4 x + \beta_7 y + \beta_9 x^2 + \beta_{10} y^2 + \cdots \\ \tau_{xy} &= \beta_5 - \beta_6 y - \beta_7 x - 2\beta_{10} xy + \cdots \end{aligned}\right\} \quad \cdots (4)$$

Equation (4) satisfies the equilibrium equations of stresses of the element as can be seen from the forms (4). Employed in the program are two types which include the terms up to $\beta_5$ and $\beta_7$ respectively.

Since each term of eqs. (1) to (4) satisfies the compatibility conditions for the adjacent elements due to the linear displacement along the sides of elements, mixed use of these elements. is possible.

*Fig.* 2 shows a comparison of stresses by his method and by beam theory applied to abeam with upper and lower face plates and with fixed end conditions. The line element (1) is used for the face plates. As is clear in the figure, stresses of the rectangular element with $\beta_5$ by the hybrid method are closest to those of the beam theory and in fact almost identical.

This is because the stress distribution is almost identical if the terms up to $\beta_5$ are used. therefore, although we cannot conclude which is the best element. an accurate result might be expected for structures like frames of a ship hull if quadrilateral elements up to $\beta_5$ of the hybrid method are used even if the division of elements is coarse

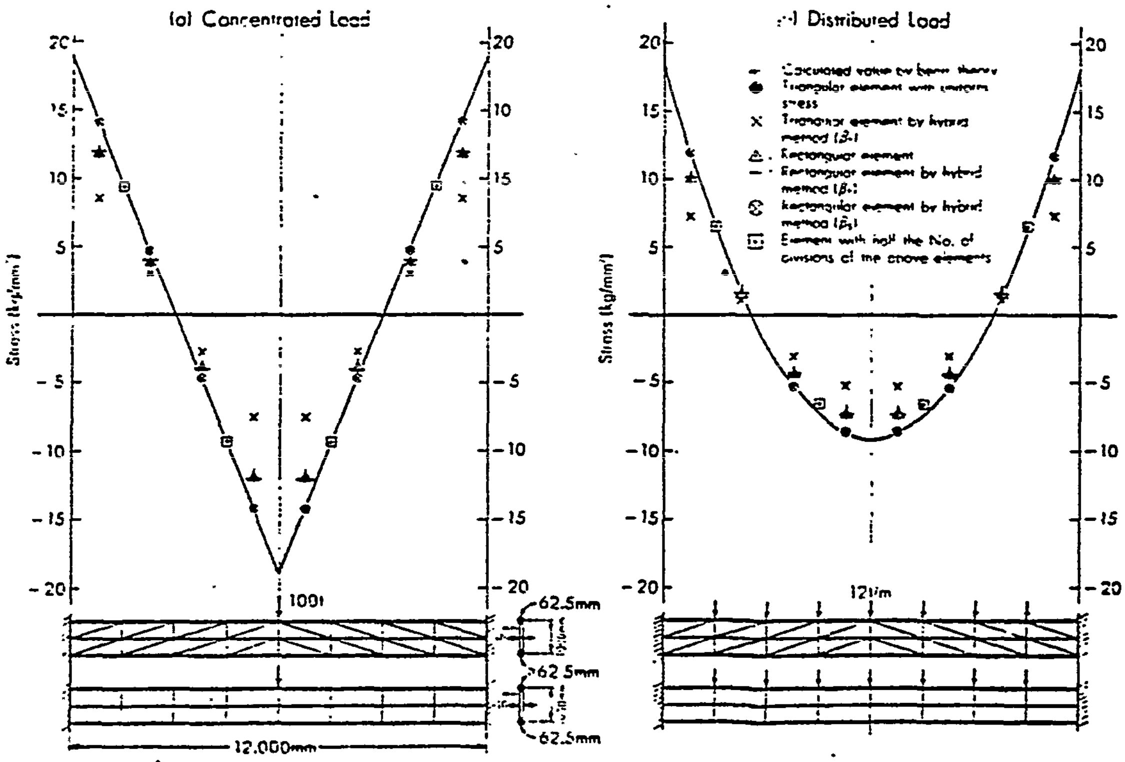



**Fig. 2** Comparison between beam theory and P.E.M. with various elements

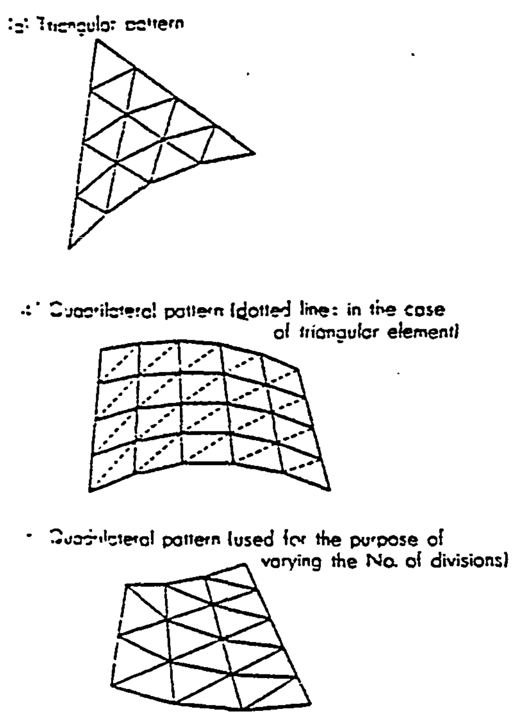



**Fig. 3 Method of automatic mesh generation**

general the rectangular element (3) seems to be greater than the rectangular element of (4). Also the rectangular element (2) and (4) give almost identical with However the latter is more useful for the stress shown of parts with stress concentration where vary distinctively since the stress distribution element can be obtained by this element.

When this program is used for structural analysis, first divide it into rectangular elements wherever it is possible. Then arbitrary quadrilateral elements are used for the parts where rectangular elements cannot be applied. Finally use triangular elements for only the part where other elements are not possible. Since automatic mesh generation within units is possible in this program. stiffness matrix or stress matrix of an element can be constructed in a single processing if the unit is rectangular. Since the same process is applied to other elements too the computer time will be shortened.

3.3 Automatic mesh generation

The fundamental patterns of units are of two types. arbitrary triangle and arbitrary quadrilateral as shown in Fig. 3. where one side of the triangle and the opposing two sides of the quadrilateral can be replaced with a circular arc. Each side is divided with equi-distance by using the number of divisions assigned in input data, and make elements as shown in the figure. The number of divisions of all sides of a triangle and of opposing two sides of a quadrilateral must be the same. Furthermore. since the number of divisions of the -boundary line between adjacent units must be the same. the determination of number of divisions is restrained. To solve this. a mesh generation patterns as in (c) of Fig. 3 is introduced.

The method of division is not only effective in the difference of labour between preparing input data of each element and preparing input data of each unit. but also convenient since it allows us to make fine mesh

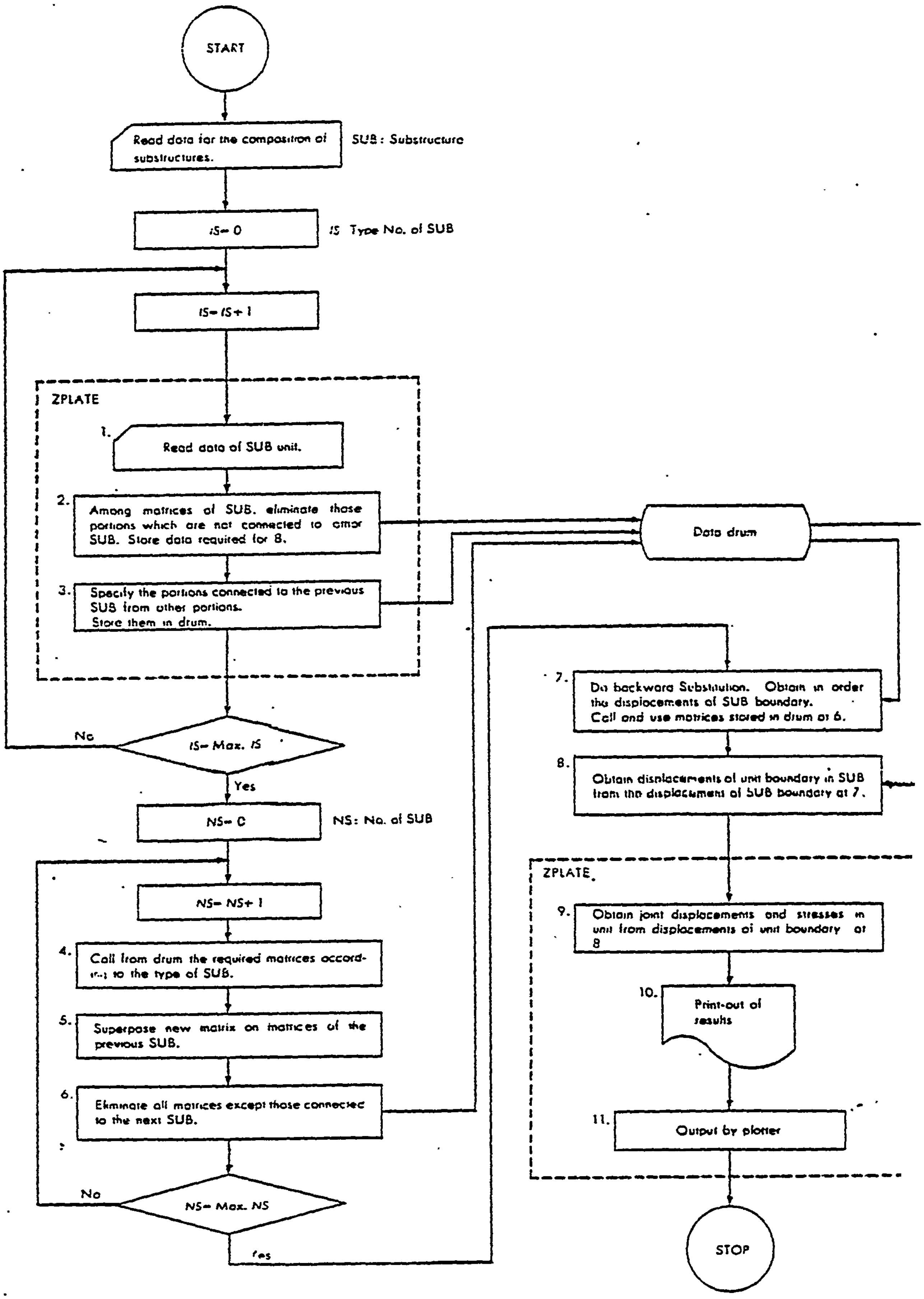



Fig. 4 Flow chart of program by substructure method

where stresses vary rapidly and to make coarse mesh wherever we have no significant change Of stresses in a similar manner to the current mesh generation when structure is idealized.

The shape of circular arc is assigned by given coordinates of an arbitrary point on a radius or circular arc. The latter method is convenient for preparing input by approximation of an arbitrary curve as a circular arc. It can be considered that this method retains the adaptablity of shape since any shape can be expressed by combination of these fundamental patterns.

3.4 **input** and output

In order to prepare input data accurately within a short time, the automatic mesh generation of elements is carried out from the viewpoint of reducing the total number of data. However more important is the faculty of the mechanism of error check. Note that the input error does not simply mean the consumptions Of computer time but means bringing about the risk of using croneous results without noticing. As in Fig. 1. data are examined for grammatical error or contradiction of' geometry and mesh generation through the error check process of the program and the error messages are printed out. Data corrected in this way proceed to the next page where coordinates of joints and arrangement of and arc examined by graphic display. The examples in Figs. 6 and **10** arc photocopies of graphic display. The program is made in such a way that a view of structures from any angle is produced on the screen of the display device by simple operation of rotating the dial, and-even some complicated structures can be examined relatively only for error of coordinates. Since the plotter draws various mesh generations ***(Fig.*** 7 and others). the shape of divided elements can be affirmed at the same time as geographical error check.

As output the displacements and stresses are printed out for each unit and displacement of joints and stresses of elements within a unit are arranged such that they correspond to the arrangement of actual joints and elements. Therefore reading of calculated results is very easy. Outputs by plotter include figures of mesh genera-l*% and displacements of joints (Fig. 7) and of principal distribution (Figs. 7 and 12) in which maximum absolute principal stresses are shown by numbers and the directions by arrow signs.

3.5 Treatment of large scale calculation

One of the problems for a program with large capacity how to handle large matrices. One advantage of INVAC-110S computer **is** the ability to use a high need magnetic drum. The random access of this magnetic drum is easy due to the treatment program and the stress time is in the order of one tenth of that of a disk.

advantage **is** made use of as an extension of the core memory. The limitation of band width is a barrier to the treatment of a large matrix in the unit division method. In this program that limitation is avoided by using a drum. This will be explained in the following paragraphs.

The process 9 of the flow chart in Fig. 1 is given as follows:

$$P = K \cdot D \quad \cdots\cdots (5)$$

$P$ = Load matrix
$K$ = Stiffness matrix
$D$ = Displacement matrix

This equation is divided into two parts; one is the part of joints connected to the front unit (Subscript-A) and the other is the part of joints to the back unit (Subscript-B) as follows:

$$\begin{bmatrix} P_A \\ P_B \end{bmatrix} = \begin{bmatrix} K_A & K_{AB} \\ K_{BA} & K_B \end{bmatrix} \cdot \begin{bmatrix} D_A \\ D_B \end{bmatrix} \quad \cdots\cdots (6)$$

Eliminating $D_A$ from eq. (6)

$$P_R = K_R \cdot D_B \quad \cdots\cdots (7)$$

In eq. (7),

$$K_R = K_B - K_{BA} \cdot K_A^{-1} \cdot K_{AB} \quad \cdots\cdots (8)$$

$$P_R = P_B - K_{BA} \cdot K_A^{-1} \cdot P_A \quad \cdots\cdots (9)$$

$K_A$ is controlled within a certain size as described in section 3.1 to calculate accurately the inverse matrix in the core. The elements associated with the subscript B vary depending upon the case or each stage of calculation. Thus, this is divided equally as follows:

$$K_R = \begin{bmatrix} K_{R,11} & K_{R,12} & K_{R,13} & \cdots \\ K_{R,21} & K_{R,22} & K_{R,23} & \cdots \\ K_{R,31} & K_{R,32} & K_{R,33} & \cdots \\ \vdots & \vdots & \vdots & \end{bmatrix} \quad \cdots\cdots (10)$$

$$K_{AB} = [K_{AB,1} K_{AB,2} K_{AB,3} \cdots\cdots] \quad \cdots\cdots (11)$$

$$K_B' = [P_{R,1}' P_{R,2}' P_{R,3}' \cdots\cdots] \quad \cdots\cdots (12)$$

An area sufficient for the treatment of one matrix thus obtained is reserved in the core and each matrix is memorized in the drum. Note that since $K_{BA}=K_{AB}'$, $K_{B,ij}=K_{B,ij}'$, these are not memorized. Since eqs. (7) and (8) are put in the forms

$$\left.\begin{aligned} K_{R,ij} &= K_{B,ij} - K_{BA,j} \cdot K_A^{-1} \cdot K_{AB,i} \\ &(i = 1, 2, 3 \cdots \; j = 1, 2, 3 \cdots) \end{aligned}\right\} \quad \cdots\cdots (13)$$

$$P_{R,i} = P_{B,i} - K_{BA,i} \cdot K_A^{-1} \cdot P_A \; (i = 1, 2, 3 \cdots) \quad \cdots (14)$$

the calculation proceeds by calling one at a time the matrices with subscripts ***i*** and j and the results are again stored in the drum. The process 10 repeats the following calculation.

$$D_A = K_A^{-1} \cdot P_A - \sum_{i=1}^{n} K_A^{-1} \cdot K_{AB,i} D_{B,i} \quad \cdots\cdots (15)$$

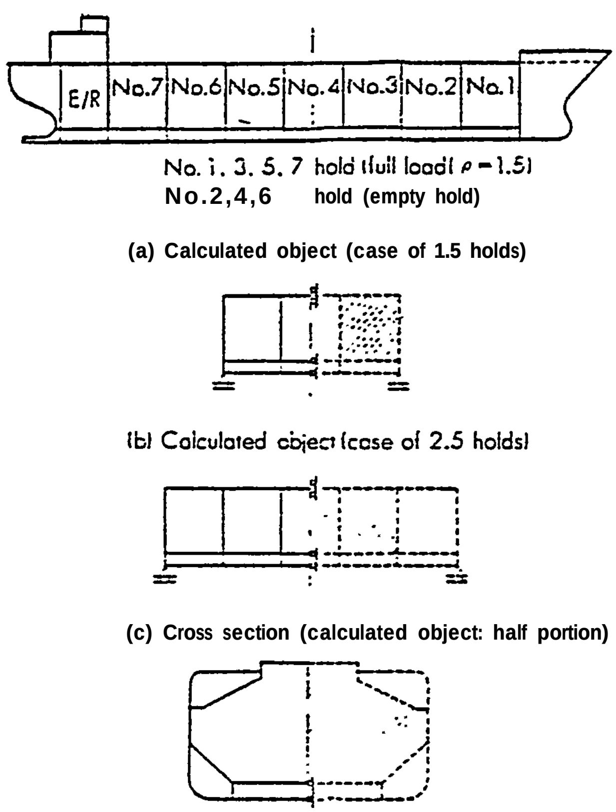
Following the above procedure any size of matrix can be treated **if the** capacity of the magnetic drum (external memory device) is sufficient In practice. however. it is wise to make **effective** use of magnetic drum since any drum capacity is limited. Consequently the required number of words must be figured out before the calculation and a process is **assigned** to put data in the drum without any blank. Especially $K_{AB}$ and $K_A^{-1}$ in the introduction process elimination **require** large

capacity of memory. As to $K_{AB}$ only non-zero element is memorized since many elements of $K_{AB}$ are zero. **Also, since** $K_A^{-1}$ is symmetric, only the upper half of the elements are memorized. As a result, even the largest matrix in the examples of application could be less than the drum capacity of 1,000,000 words. By the way, the core capacity is 65K words at present.

3.6 Substructure method

As described in the foregoing section, the computer time in the analysis of ship hull structures with periodic identical pattern can be largely reduced by common use of data and stiffness matrices by taking into consideration the periodic characteristics. In this case, the identical pattern is called substructure. Actual structures are composed of several types of substructures and in many cases they repeat periodically. The flow chart of the program by the substructure method is illustrated in ***Fig.*** 4, where the parts designated by ZPLATE imply using the ***necessary*** part of the program of ***Fig. 1.*** The other parts of the processes are also the same as those of the previous section in the basic consideration.

Regarding the substructure method, consider the problem of idealization of structures. As to ship hull structures, saving labour in preparation of data can be furthered by standardization of the frame patterns dependent upon the ship hull such as on tankers or ore carriers. In the example of a bulk carrier described later, the substructures are constructed quite arbitrarily. In this case, the time needed to prepare the input data increases, but it does not require a certain type of ship hull structure and can be applied to any other structure. If they can be respectively called specific and general purpose programs, then the natural order is to first develop the general purpose and then extend it to the specific purpose. However, it is noted that the larger the increase in efficiency of the specific purpose, the more restrained is the idealization of structures. Important to designers are the idealization of structures and the interpretation of results by finite element method. In the case of finite element method, it is required to introduce some approximations based on various assumptions although the idealization is comparatively easy. It seems that these problems should be determined by taking into consideration the characteristics of each structure. At the same time, it is instructive for designers to reevaluate the structural composition through the idealization process. in the future, the specification is expected to progress during the stage where the finite element method ***is*** introduced to the design process. However, at present which is stil1 the transient stage, it seems necessary to make ful1 use of the general purpose program.




No. 1, 3, 5, 7 hold (full load/ $\rho = 1.5$)
No.2,4,6 hold (empty hold)

**(a) Calculated object (case of 1.5 holds)**

(b) Calculated object (case of 2.5 holds)

**(c) Cross section (calculated object: half portion)**

**Fig. 5 Loading and bound conditions of bulk carrier**

## 4. Applications

As applications of the ZPLATE program. the results of three-dimensional stress analysis of a bulk carrier and longitudinal stress analysis of a destroyer are presented below.

4.1 Three-dimensiona1 stress analysis of hull: carrier

The test hull is a bulk carrier of 44,500 DWT with the following principal dimensions.

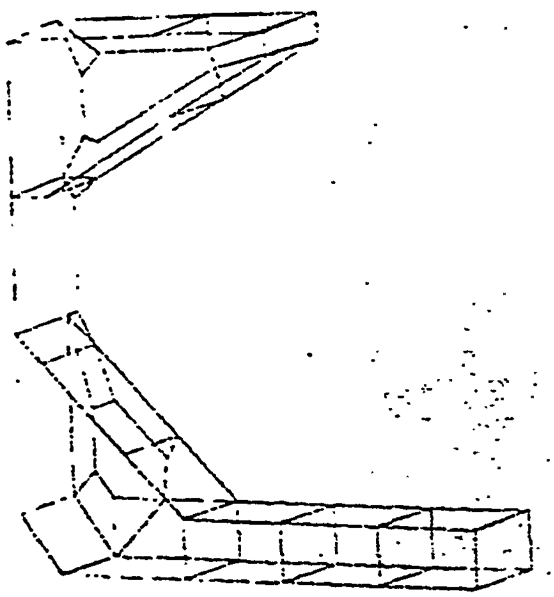
L x B x D x d = 190 x 30 x l6 x l1.55m

The models used for the calculations are two types with 1.5 and 2.5 holds respectively (corresponding to 3 and 5 holds if the symmetric property is considered). As to the 1.5 hold, two types of coarse mesh and fine mesh, or a total of three types, are analyzed ***(Fig. 7).*** Alternate loading at fuIl draft is employed. The sizes of the three types in the analysis are shown in ***Table 1.***

***4.1.1 Assumption of calculation and preparation of input data***

For the preparation of input data, the substructure method described above is employed. ***Fig. 6*** shows copies of the shapes of substructures checked by graphic display. For instance, two types of substructure ((a) and (b) of ***Fig.*** 6) are prepared and then are orderly connected into the structure shown in (c) of the same figure. The analysis ***was*** carried out on the final structure. The figure shows the profile of the units where the elements are further divided into fine mesh. The details of the mesh of each part of the structure are shown in (a) and (b) of ***Fig. 7.***

Although each member **is** treated as a plate, the face plates of the transverse rings and the bulkhead **stiffeners are** assumed to be line elements and the plate with longitudinal beams is treated as an orthotropic plate with increased thickness. The adjustment of **size** is made



g. 6 (a) Idealization of bulk carrier (substructure of transverse ring)

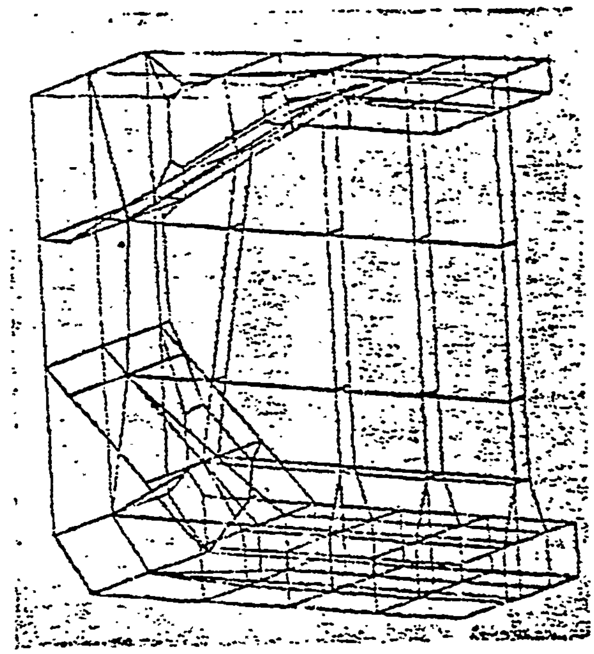


Fig. 6 (b) Idealization of bulk carrier (substructure of bulkhead

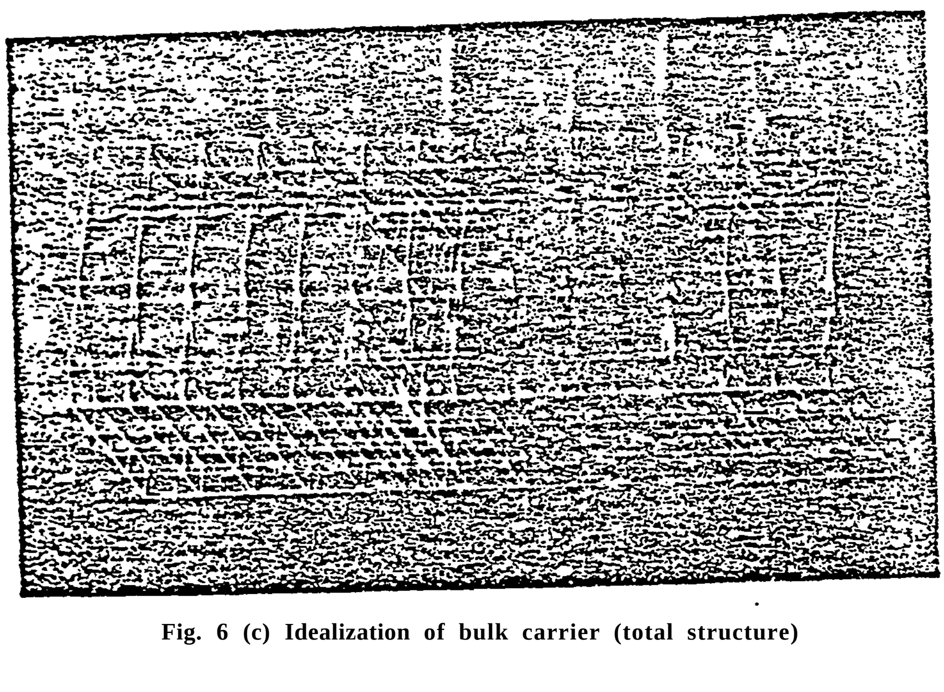
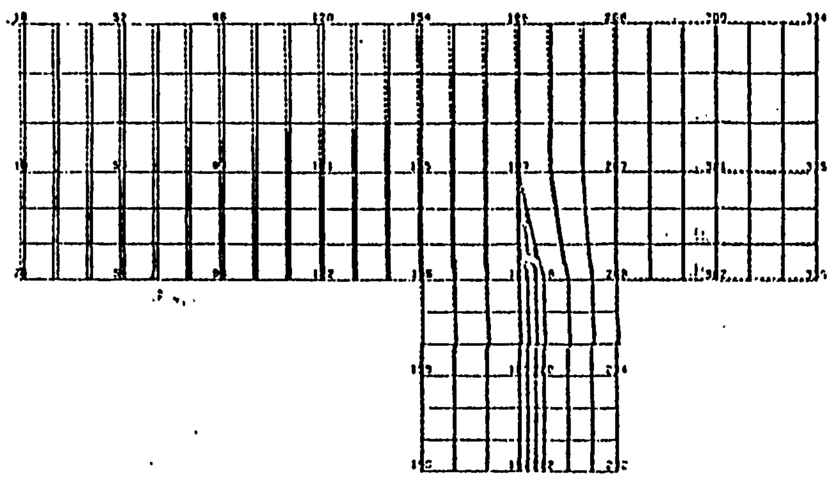


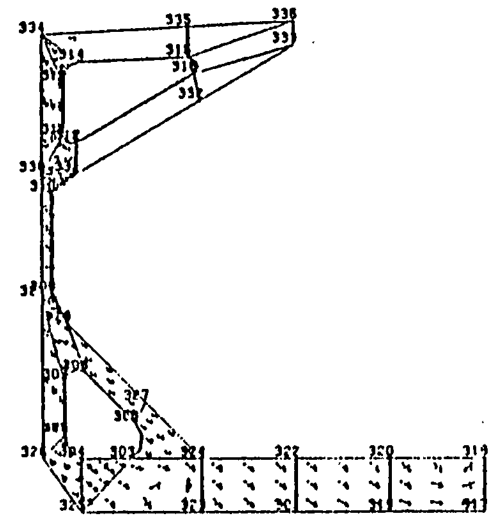
Fig. 6 (c) Idealization of bulk carrier (total structure)

Table 1 Size of claculation of bulk carrier

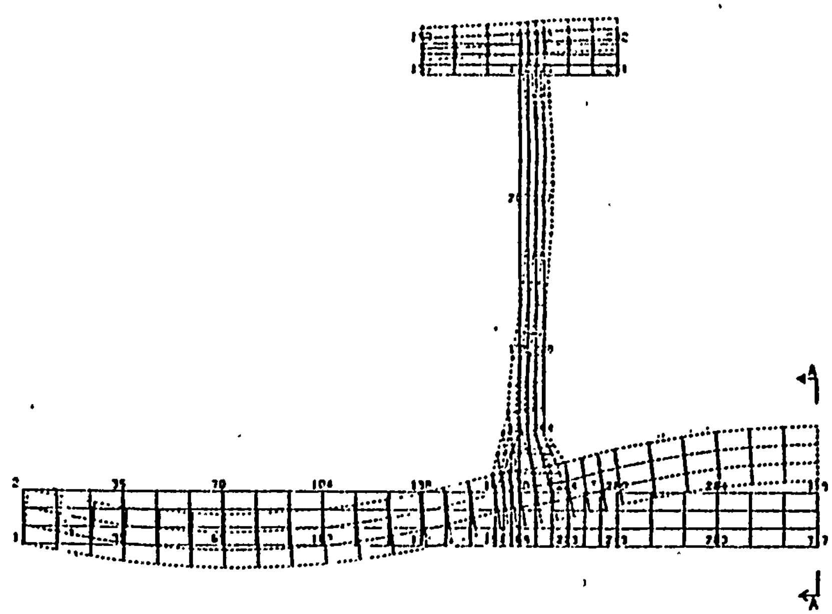
| Items / Calculation scope | Mesh generation | No. of unit | No. of element | No. of joint | Degrees of freedom |
|---|---|---|---|---|---|
| 1.5 hold | Coarse mesh | 444 | 1,776 | 1,511 | 4,347 |
| // | Fine mesh | // | 3,996 | 3,534 | 10,323 |
| 2.5 hold | Coarse mesh | 798 | 3,192 | 2,640 | 7,680 |

UPPER DECK PLAN

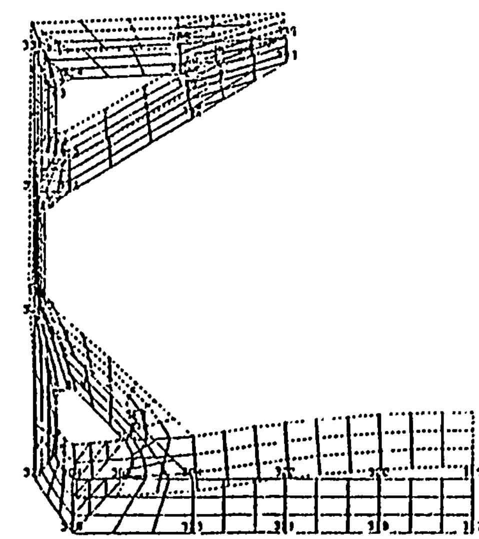




CENTER LINE SECTION



TRANS. RING
(A-A SEC.)



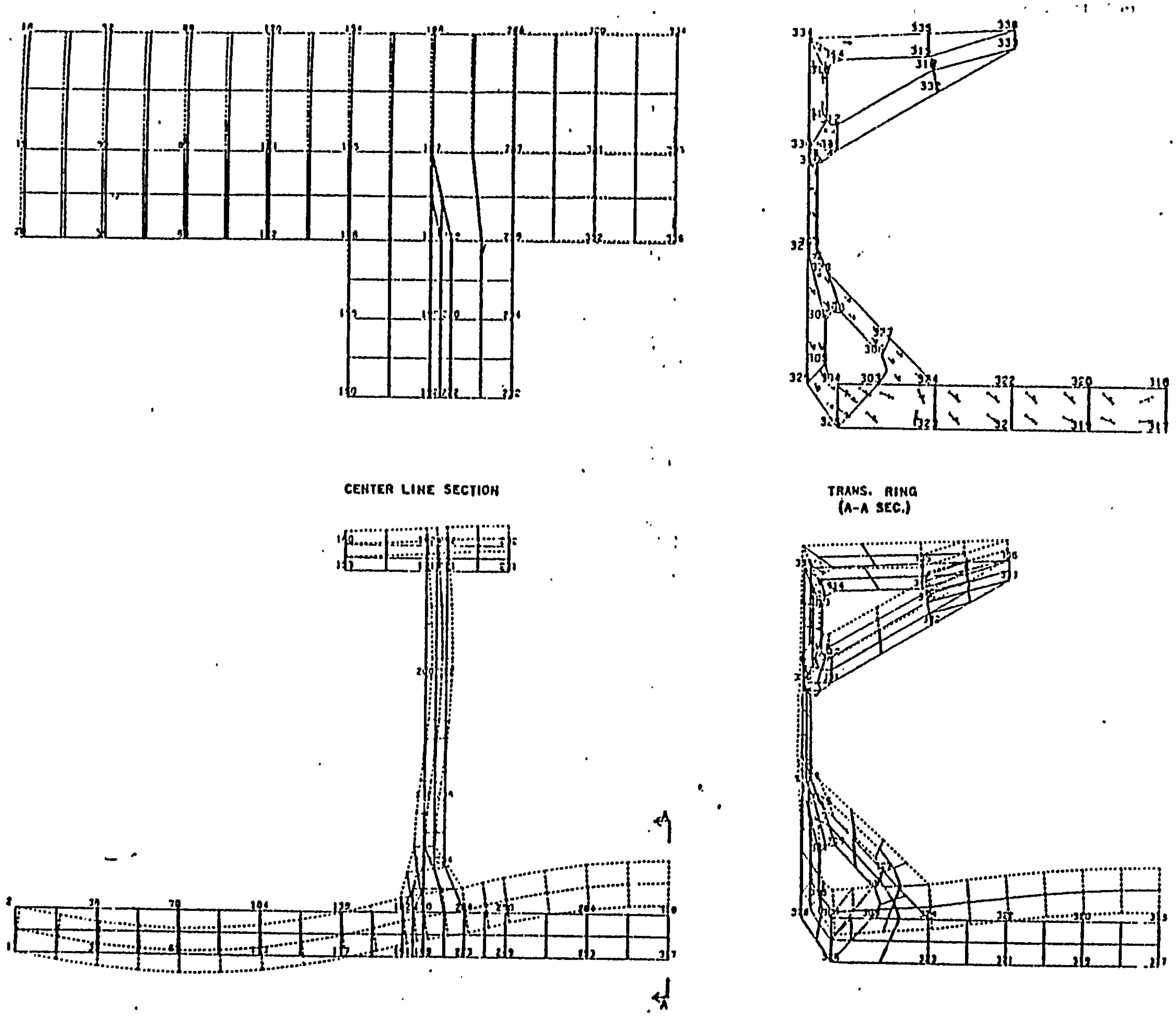



Fig. 7 (b) Results of calculation (coarse mesh)

asuming transverse rings as one unified ring and four frames as a unit. The objectives of the analysis are first to make a rough estimation of displacement of each part such as double bottom floor and hopper and then, with the results, to recalculate stresses of the transverse rings or the frames as the local stress analysis. The idealization is responsible to the above objectives.

In this analysis, we used mostly quadrilateral elements by the hybrid method, together with partial triangular elements of uniform stress. Most of the input data are common to the analysis of the three types. It took about five days for one person to prepare the data.

4.1.2 *Results of calculation*

Described in the following arc the way of mesh generation and the effect of adjacent holds on the three-dimensional stress analysis of a bulk carrier.

***Fig.*** 8 shows a comparison of stresses at the section of No. 4 hold center for two cases of coarse and fine mesh of 1.5 hold models. As seen in the figure, almost no difference can be recognized but the stresses at the transverse ring and frame are slightly different. However, this is mainly due to the idealization described in the section "Assumption of Calculation". In order to evaluate the local stresses, the zooming method"' may be applied in which the part in question is taken out into small mesh. Therefore, the error of this order may be negligible in reality. The displacement is not different at all for the two cases arc seen in ***Fig. 7.***

***Fig.*** 9 shows a comparison of stresses at the same section of No. 4 hold center for the two casts of 1.5 and 2.5 hold models, to examine the effect of the adjacent holds. Again, no difference can be seen. The end conditions of each case are both simple supports at the front of the bulkhead. For the alternate loading,, the assumption does not affect the adjacent hold. ***Since*** the effect of longitudinal stresses of the front and rear holds is not taken into consideration, the stresses of longitudinal members art quite different. However, it does not affect stresses on the cross section as seen in the results.

The following conclusions are drawn from the analysis.

1. The effect of the end boundary condition of the hold adjacent to the inspection hold is comparatively Small
2. Even the coarse mesh of this example gives very good-results as far as the hybrid mesh is used.

A bulk carrier has a complicated structure compared with a tanker and there are many unknown problems as to the effect of the shape of hopper tank and the type of hull, etc., on the overall strength. Therefore it is not ***permissible*** to draw. from the example, conclusions on the general analytical method. It is necessary to establish the three-dimensional stress analysis of finite element method by ***further*** studying bulk carriers of various types and boundary conditions.

4.2 Example of stress analyses of ship hull with long deck house

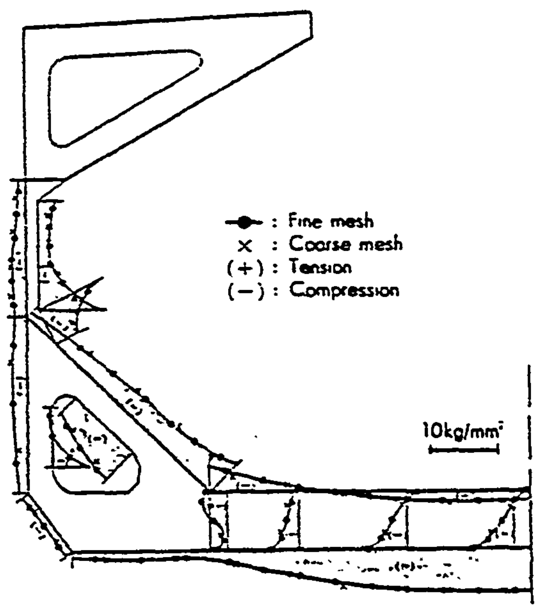



**Fig. 8** **Comparison of stress at section of No. 4 hold center between the mesh and coarse mesh of 1.5 hole models**

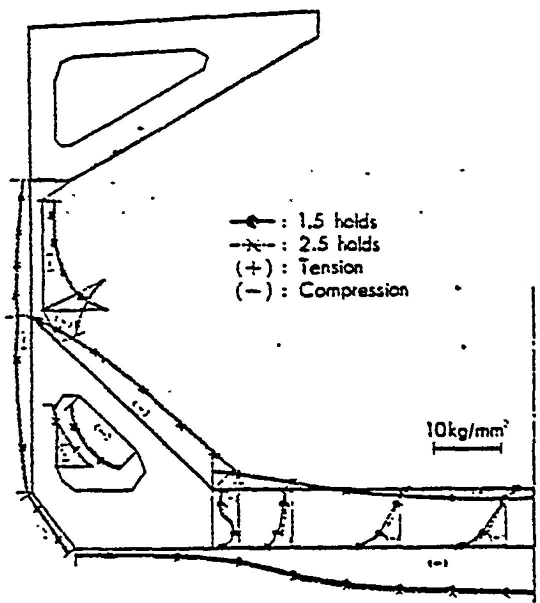



**Fig. 9** **Comparison of stress at section of No. 4 hold center between I.5 hold model and 2.5 hold model**

**Fig. 10** idealization **of destroyer**

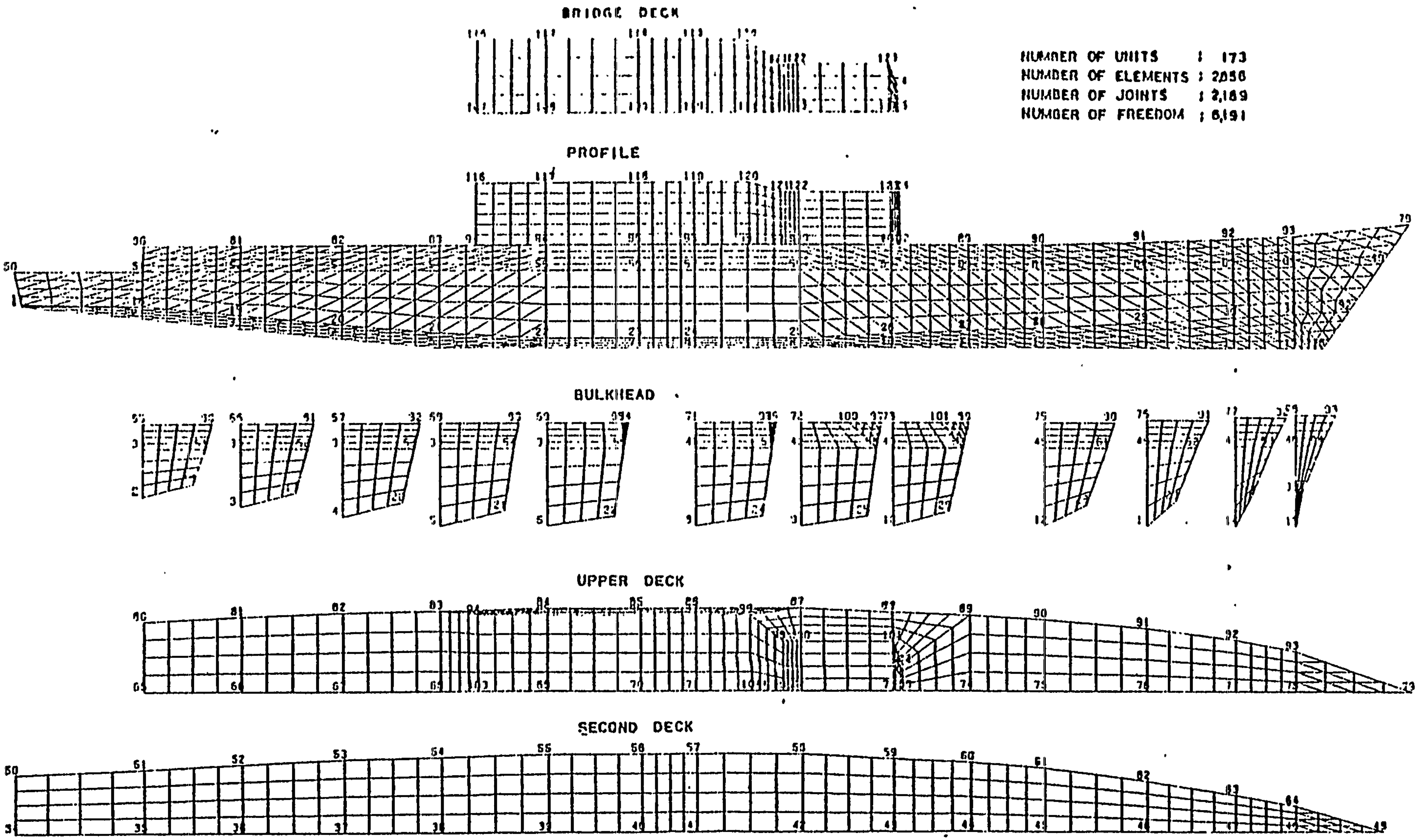
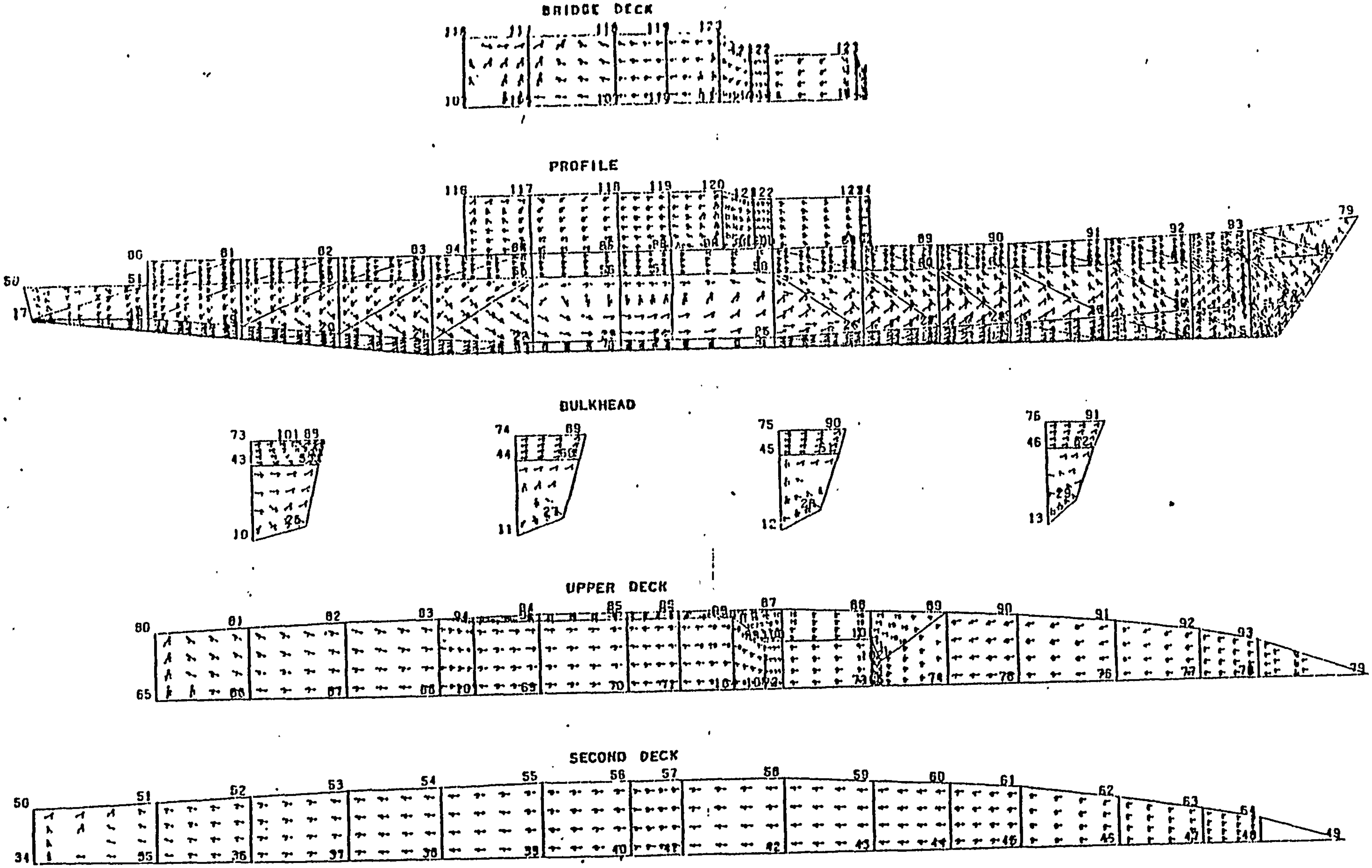



Fig. 11 Mesh layout




(Note) Arrow: Direction of principal stress
←→ : Tension side
)–( : Compression side

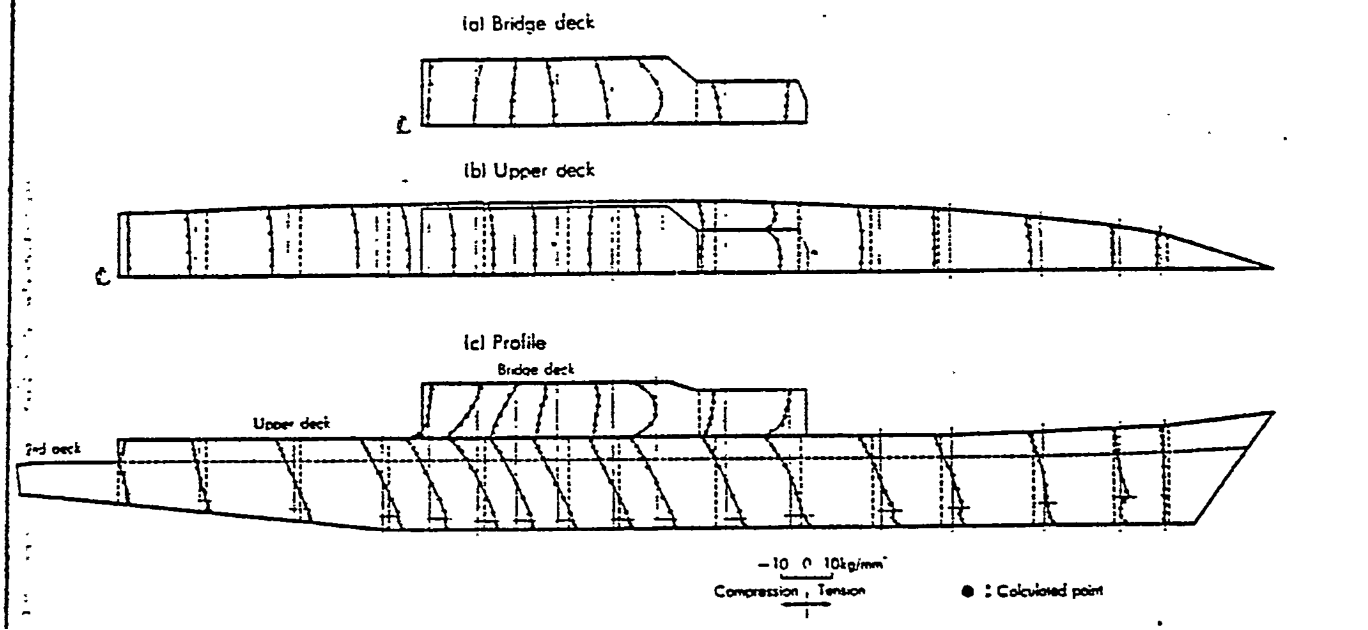



**Fig. 13 Distribution of longitudinal stress of hull structure (hogging condition)**

The longitudinal stresses of a ship hull are currently ...ired by assuming the hull as a beam with both ...s free. Because of shear lag, the results may be ... different from the actual stress distribution if the ... hull with a long deck house is simply treatcd as ...m of varying section. Although methods Of an-...s[4), (5), (6)] are studied on the interaction of deck ... and ship hull, they cannot be applied directly to ... ship hull structures because of the simplified idea-...tion of deck house and ship hull. However, ideaiiza-... close to the real structures is possible by the finite ...nt method[7]. Presented in this section is the ...ysis on a destroyer with a long deck house. Since ...ffect of the deck house is great on the longitudinal ...ses of the ship hull structure in this case. stress ...ntration is produced at the ends of the deck ... and quite large stresses can be seen. Therefore. ...ccessary to reinforce the part or to provide movable ...s to the deck house.

*4.2.1 Assumption of calculation*

1. In this analysis, only a single side of the structure can be considered since both the structure and loading conditions are *symmetric* with respect to both sides. As in *Fig.* 10, the ship hull is divided into a structure composed of flat plates so that the idealization is as close to the actual structure as possible. Treating these places as units. and applying the automatic mesh generation to the units. the mesh layout shown in Fig. *11* is obtained.
2. Tine longitudinal members attached to the side shell deck, deck plate and side wall of the deck house arc assumed as orthotropic plates. The stiffeners of the transverse bulkheads are also treated as orthotropic plates and the in-plane stiffness is taken into account.
3. As to loading, the load in the vertical direction of the ship hull is applied and distributed upon the lower end of the side shell under hogging condition Where the crest of the wave of one twentieth the ship length locates at the midship.
4. As boundary conditions, the *lower* end of side shell is supported vertically at both ends. One oF the ends is also supported longitudinally. Since the actual reactions at the two points are close to zero, we can examine the loading conditions. Furthermore taking the symmetry of the structure and loading into consideration, we assumed that the plate is supported in the transverse direction at the center line of the ship hull and is free in the vertical direction.
5. Used in the analysis are quadrilateral element for the hybrid method and triangular element for the uniform stress.

***42.2 Results of calcualtion***

Fig. 12 shows the distribution of principal stresses of each part of the ship hull structure. ***Fig. 23*** shows the distribution of longitudinal stresses of the ship hull structure. As can be ***seen*** in ***Fig. 13,*** the deck house affects very much the longitudinal stresses of the ship hull and the distribution is quite complicated since the side wall of the deck house and the deck plate are not on the same plane. For analysis of the stress concentration at the ends of deck plate, the mesh layout of this example is too coarse to obtain accurate results. Accordingly. the zooming method may be applicable in this case. The study is not given in this paper. However, we can see some stress concentration at the ends of the deck house even in the given mesh layout.

## 5. Conclusions

A general purpose computer program designated ZPLATE was described for the plane ***stress* analysis** of plane and three-dimensional structures through finite element method As applications, the three dimensional stress analysis of a bulk carrier and the longitudinal stress analysis of a destroyer with a long deck house were presented. In the development of the program, we intended to obtain a program with large capacity which is sufficient for practical use and whose scale is balanced with the faculty of saving labour in preparation of input data and in analysis of calculated results. In this paper, examples with 4,000 to more than 10,000 degrees of freedom in calculation are presented. However, this program can solve these examples within a few days. We believe therefore that our initial objectives have been attained satisfactorily. The future problem is to extend the program to those which include analysis of out-of-plane bending, buckljng, vibration and e!asto-plasticity.

REFERENCES


(1) Shinohara, Y.. "Seminar of Matrix Method Structural Analysis" (5), Outline of FRAN. JSS( Vol. 3 No. 18, 1967 in Japanese.

(2) R.W. Clough: The finite element **in** plane Stres analysis A.S.C.E. Conf. on Electronic Compu tion. Pittsburg Pa, (1960.9).

3) T.H.H. Plan: Derivation of element stifiner matrices by assumed stress distribution J.A.1.A.f 2 (1964.7) p. 1,33-1.336.

(4) H.H. Bleich: Nonlinear distribution of bendir stress due to distortion of the cross section Journ of Applied Mechanics (1953.3).

(5) Yagi. J.,: Investigation of effect of upper stru tures (No. l-6) proceedings of Naval Arch. of Jap: No. 100-103, 105, 106 (Nov., 1956-Jan, 1960).

(6) J.C. Chapman: The behaviour of long deck hou The Royal Institution of Naval Architects Qua Trans., Vol 103 No. 4 (1961.10).

(7) J.R. Pauling & H.G. Payer Hull-Deckhouse interaction by finite element calculation, Tray S.N.A.M.E. Vol. 76 (1968.11).

## APPENDIX P

## Z VIBRA - MATRIX-METHOD OF VIBRATIONAL ANALYSIS OF FRAMED STRUCTURES, AND ITS APPLICATION

UDC 624.042: 629.12.032: 539.145.43

# Matrix Method of Vibrational Analysis of framed Structures and its Application

Isao Neki*

*Recently, with the matrix method, analysis of elastic, plastic, vibrational or buckling problems* **of framed** *structures widely diffused in the various field of structural design, plus analysis of complex three-dimentional frames structures are becoming daily routine work. A computer program designated ZVIBRA. for vibrational analysis of three-dimensional framed structures, has been devcloped. using the stiffness matrix method of the author. The present paper* outlines *the ZVIBRA program with some examples of its application. The program aims at analysis of elastic, vibrational responses of sinusoidal forced-loaded frames. including the influence of* shear ***rigidity and*** rotatory ***inertia, which should be particularly useful for*** analysing ***ship hull*** structures.

## 1. Introduction

In recent years, with the matrix method, analysis of clastic. plastic, vibrational or buckling problems of framed structures which are broadly diffused in the various fields has come into wide use. and-by the use of this method the analysis of complex three-dimensional framed structures are becoming daily routine work. The author has developed a computer program ZVIBRA. for vibrational analysis of three-dimensional framed structures, using the stiffness matrix method. Therefore its outline and examples of its application will be presented here with an intention to place it at the service of the interested public.

ZVIBRA has been prepared for analysis of vibrational responses in elastic range of three-dimensional framed structures under sinusoidal forced vibration. Because the of effects of shear rigidity and rotatory inertia are taken into consideration. this ***method*** is particularly effective in the analysis of structures such as the ship hull structures where the effects of those factors cannot be ignored.

For vibrational analysis method of framed structures, a method in general use obtains natural frequencies in free vibration by replacing the structure to be analysed with a structure made up of multiple masses and spring system. However in framed structures where shearing deformation and rotatory inertia are taken into consideration. it is extremely difficult to obtain natural values by the use of the above method. Moreover, in replacing the structure with that of a multiple masses and spring system, adequate precision can not be obtained unless the members are approximated by as many masses and spring as possible. In consideration of the above fattors. the author has assumed the framed structures to be a conglomerate of beams. which have infinite degree of freedom. and then their stiffness matrices were obtained, Using such matrices, their vibrational responses were calculated and as a result their vibrational modes and amplitudes were obtained. Accordingly. since the natural frequencies can not be obtained under this method, vibrational responses corresponding to the number of vibrations at the necessary number of points were obtained. then by reviewing the increase or decrease of vibrational amplitudes as well as the phase change of vibrational modes. the natural values can be obtained.

Naval & Special Ship Design Dept. Ships Division

## 2. Solving method

2.1 Application and assumptions

The application and assumptions used in this program are outlined as follows:

1. The objective is the vibrational analysis of framed structures in elastic range under varying loads (including forced displacements) of sinusoidal form with a constant amplitude. The framed structures defined here are structures consisting of joints and straight members between joints, with uniform cross sectional areas. The members are assumed as ideal lings, neglesting the thickness. and the joints are assumed as ideal points. Therefore, the structures consisting of plates. curved bums, and tepered beams have to be analysed as struttures consisting of ***respectively*** equivalent beams by using proper approximation method, following the above assumptions.

2. The ends of the members of the framed structures can be pins, rollers, spring-supported, built-in connections, rigid attachments or free-ends. For loading conditions, the concentrated loads applied on joints

and the forced displacements at joints will be considered.

3. For vibrational mass. the dead weight of beams. the added mass uniformly distributed over the beams and the concentrated mass at joints will be, considered.

4. Damping factor of structures is not considered. Therefore. the amplitudes near the resonance point will become considerably larger than the actual values. However. at points 10% apart from the resonance frequency. it is safe to think that the amplitudes in the ordinary structures will be quite close to the actual valvues. even if damping factor is not considered.

5. The results of analysis calculated will be: The displacements and angular deflections at all joints, the displacements and angular deflections at quarter points of each member. stresses at ends each member. support reactions. etc. When necessary, vibrational mode curves of each structure can be plotted by the use of a plotter.

6. As for the analysis method. the stiffness matrix method derived from the displacement method is used, and by analysis of vibrational responses (but not taking into account of damping factor) the vibrational modes at the desired vibrational frequency are examined, and also by calculating at several levels of vibrational frequency the resonance frequency can be found.

2.2 Stiffness matrix for vibration of beams having uniform cross section

Stiffness matrix of beams having uniform cross section is obtained. when sinusoidal forced load is applied at each end. where bending, shearing, torsion, elongation and rotatory inertia are taken into account. The symbols used in the equations will have the following meaning:

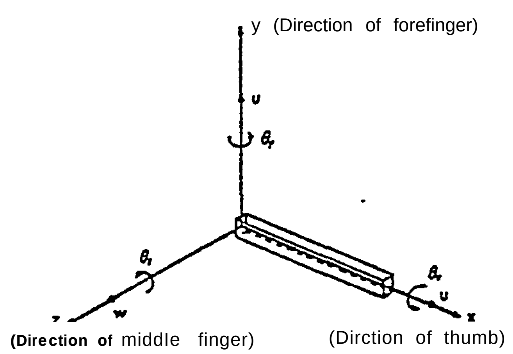



Fig. 1 Right handed coordinate system adapted in present study

X: Coordinate in the direction along the length of beam.

$y$, $z$: Coordinates perpendicular to the beam, in accordance with the right handed coordinate system (See in Fig. 1)

U: Displacement in x direction

T: Displacement in y direction

$w$: Displacement in : direction

$v_B$: Displacement only due to bending in y direction

$w_B$: Displacement only due to bending in : direction

$\theta_x$: Angle of rotation around x axis

$\theta_y$: Angle of rotation around y axis

$\theta_z$: Angie of rotation around z axis

$GJ$: Torsional stiffness of beam

$EI_y$: Bending stiffness of beam around y axis

$EI_z$: Bending stiffness of beam around z axis

$A_x$: Cross sectional area of beam

$GA_y$: Shearing stiffness of beam in y direction

$GA_z$: Shearing stiffness of beam in z direction

$\mu$: Weight of beam per unit length

$I_{mx}$: Rotatory inertia of beam per unit length around x axis

Rotatory-inertia of beam per unit length around y axis

Rotatory inertia of beam per unit length around z axis

l: Total length

w: Forced circular frequency

$F_x$: Axial force in x axis direction

Fy: Shearing force in y axis direction

Fz: Shearing force in z axis direction

Mx: Torsional moment around x axis

My: Bending moment around y axis

Mz: Bending moment around z axis

m: Mass of concentrated material paint at joint.

$J_x$: Rotatory inertia of concentrated mass at joint around x axis

Jy: Rotatory inertia of concentrated mass at joint around y axis

$J_z$: Rotatory inertia of concentrated mass at joint around z axis

XG: Distance from joint to Center of Gravity of concentrated mass in x axis direction

JG: Distance from joint to Center of Gravity Of concentrated mass in Y axis direction

$z_G$: Distance from joint to Center of Gravity of concentrated mass in z axis direction

$k_x$: Spring constant of support joint in x axis direction

$k_y$: Spring constant of support joint in y axis direction

$k_z$: Spring constant of support joint in z axis direction

$k_{mx}$: Torsional spring constant of support joint around x axis

$k_{my}$: Torsional spring constant of support joint around y axis

$k_{:}$: Torsional spring constant of support joint around z axis

(1) Longitudinal vibration of beam.

Let

$$EA_x \frac{\partial^2 u}{\partial x^2} - \frac{\mu}{g}\frac{\partial^2 u}{\partial t^2} = 0 \quad \cdots\cdots\cdots\cdots (1)$$

$$u = u_0(x)\sin\omega t \quad \cdots\cdots(2)$$

and substitute equation (2) into (I)

$$\frac{d^2u_0}{dx^2} - \alpha^2 u_0 = 0 \quad \cdots\cdots(3)$$

where, $\alpha^2 = \omega^2\mu/EA_x g$

Therefore. the solution of equation (3) can be given by the next equation

$$u_0(x) = A_1\cos\alpha x - A_2\sin\alpha x \quad \cdots\cdots(4)$$

A1, A2: constant of integration.

(2) Lateral vibration of beam

The lateral vibration of beam having uniform cross section, where bending, shearing and rotatory inertia are taken into account, can be expressed as follows, according to the well known equation" of Timoshenko Firstly, the lateral vibration in y direction can be expressed by the next equation

$$\frac{\partial^4 v}{\partial x^4} - \left(\frac{b_z}{p_z} + \frac{a}{q_y}\right)\frac{\partial^4 v}{\partial x^2\partial t^2} + \left(\frac{a}{p_z}\frac{\partial^2 v}{\partial t^2} + \frac{b_z}{q_y}\frac{\partial^4 v}{\partial t^4}\right) = 0 \quad \cdots\cdots(5)$$

Here, since

$$a = \frac{\mu}{g}, \quad b_z = \frac{I_{mz}}{g}, \quad p_z = EI_z, \quad q_y = GA_y$$

let $v = v_0(x)\sin\omega t \quad \cdots\cdots(6)$

and substitute in equation (5)

$$\frac{d^4 v_0}{dx^4} + 2k_{1y}\frac{d^2 v_0}{dx^2} + k_{2y} v_0 = 0 \quad \cdots\cdots(7)$$

where;

$$2k_{1y} = \left(\frac{b_y}{p_z} + \frac{a}{q_y}\right)\cdot\omega^2 \quad \cdots\cdots(8)$$

$$k_{2y} = \frac{a}{p_z}\left(-\omega^2 + \frac{b_z}{q_y}\omega^4\right) \quad \cdots\cdots(9)$$

Hence. equation (7) can be expressed by the next equation

$$v_0(x) = C_1\cosh m_1 x + C_1\cos\sinh m_1 x + C_3\cos m_2 x + C_4\sin m_2 x \quad \cdots(10)$$

$C_1, C_2, C_3, C_4$: constant of integration

$$m_1 = \sqrt{\sqrt{k_{1z}^2 - k_{2y}} - k_{1y}},$$

$$m_2 = \sqrt{\sqrt{k_{1y}^2 - k_{2y}} + k_{1y}}$$

In the similar manner, the lateral vibration in z direction to be obtained as below.

$$w = w_0(x)\sin\omega t \quad \cdots\cdots(11)$$

$$w_0(x) = D_1\cosh n_1 x + D_2\sinh n_1 x + D_3 + D_4\cos n_2 x\sin n_2 x \quad \cdots\cdots(12)$$

$D_1, D_2, D_3, D_4$: constant of integration

$$n_1 = \sqrt{\sqrt{k_{1z}^2 - k_{2z}} - k_{1z}},$$

$$n_2 = \sqrt{\sqrt{k_{1z}^2 - k_{2z}} + k_{1z}}$$

$$2k_{1z} = \left(\frac{b_z}{p_y} + \frac{a}{q_z}\right)\cdot\omega^2$$

$$k_{2z} = \frac{a}{p_z}\left(-\omega^2 + \frac{b_z}{q_z}\omega^4\right)$$

$$b_y = \frac{I_{my}}{g}, \quad p_y = EI_y, \quad q_z = GA_z$$

(3) Torsional vibration of beam

let

$$GJ\frac{\partial^2\theta_x}{\partial x^2} - \frac{J_{mx}}{g}\frac{\partial^2\theta_x}{\partial t^2} = 0 \quad \cdots\cdots(13)$$

$$\theta_y = \theta_{x0}(x)\sin\omega t \quad \cdots\cdots(14)$$

and substitute (14) into equation (13)

$$\frac{d^2\theta_{x0}}{dx^2} - \beta^2\theta_{x0} = 0 \quad \cdots\cdots(15)$$

where; $\beta_2 = \omega^2 I_{mx}/GJg$

Therefore the solution of equation (is) canbe given by the next equation

$$\theta_{x0}(x) = B_1\cos\beta x + B_2\sin\beta x \quad \cdots\cdots(16)$$

$B_1, B_2$: Constant of integration

(4) Stiffness matrix

Stiffness matrix is obtained by using equations (4). (1O), (12). (16).

Firstly, let

$$\left.\begin{aligned} F_x &= F_{x0}(x)\sin\omega t & M_x &= M_{x0}(x)\sin\omega t \\ F_y &= F_{y0}(x)\sin\omega t & M_y &= M_{y0}(x)\sin\omega t \\ F_z &= F_{z0}(x)\sin\omega t & M_z &= M_{z0}(x)\sin\omega t \end{aligned}\right\} \quad \cdots\cdots(17)$$

Here, considering that

$$\left.\begin{aligned} \theta_y &= -\frac{dw_B}{dx}, \quad M_y = EI_z\frac{d^2 w_B}{dx^2}, \\ F_y &= -GA_y\frac{d^2(v - v_B)}{dx^2} \\ \theta_z &= \frac{dv_B}{dx}, \quad M_z = -EI_y\frac{d^2 v_B}{dx^2}, \\ F_z &= -GA_z\frac{d^2(w - w_B)}{dx^2} \end{aligned}\right\} \quad \cdots\cdots(18)$$

where the related equations[3][4], obtained by using compatibility conditions of the displacement and equibrium of forces, arc expressed in matrix form, it will become as follows:

$$
\begin{pmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \theta_{y0} \\ \theta_{z0} \\ F_{x0} \\ F_{y0} \\ F_{z0} \\ M_{x0} \\ M_{y0} \\ M_{z0} \end{pmatrix}
=
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & -\left(1+\frac{ap_y}{q_z}\omega^2\right)\frac{1}{C_z} & 0 & 0 & 0 & -\frac{p_y}{q_z C_z} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \left(1+\frac{ap_z}{q_y}\omega^2\right)\frac{1}{C_y} & 0 & \frac{p_z}{q_y C_y} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & -GA_x & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \left(\frac{ap_z}{q_y}+b_z\right)\frac{\omega^2}{C_y} & 0 & \frac{p_z}{C_y} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \left(\frac{ap_y}{q_z}+c_y\right)\frac{\omega^2}{C_z} & 0 & 0 & 0 & \frac{p_y}{C_z} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -GJ & 0 & 0 \\
0 & 0 & \frac{ap_y}{q_z}\omega^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & p_y & 0 \\
0 & -\frac{ap_z}{q_y}\omega^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -p_z
\end{pmatrix}
\begin{pmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \frac{dw_0}{dx} \\ \frac{dv_0}{dx} \\ \frac{du_0}{dx} \\ \frac{d^3v_0}{dx^3} \\ \frac{d^3w_0}{dx^3} \\ \frac{d\theta_{0x}}{dx^2} \\ \frac{d^2w_0}{dx^2} \\ \frac{d^2v_0}{dx^2} \end{pmatrix}
\quad \cdots(19)
$$

where $C_y=\left(1-\frac{b_z}{q_y}\omega^2\right)$, $C_z=\left(1-\frac{b_y}{q_z}\omega^2\right)$

The equation (19) shall be rewritten in the form of next equation

$$
\begin{bmatrix} D(x) \\ F(x) \end{bmatrix} = B \begin{bmatrix} H_1(x) \\ H_2(x) \end{bmatrix} \quad \cdots\cdots(20)
$$

Where D(x), H1(x) are from the top to the 6th row. and F(x), H2(x) are the last 6 rows. Then, by using quations (4), (IO), (12), (16), the next equation can be 0btained.

Equation (21) will be expressed as in the next equation

$$
\begin{bmatrix} H_1(x) \\ H_2(x) \end{bmatrix} = L(x)\cdot C \quad \cdots\cdots(22)
$$

By substituting equation (22) into equation (20), the following can be obtained:

$$
\begin{bmatrix} D(x) \\ F(x) \end{bmatrix} = B\cdot L(x)\cdot C \quad \cdots\cdots(23)
$$

$$
\begin{pmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \frac{dw_0}{dx} \\ \frac{dv_0}{dx} \\ \frac{du_0}{dx} \\ \frac{d^3v_0}{dx^3} \\ \frac{d^3w_0}{dx^3} \\ \frac{d\theta_0 x}{dx} \\ \frac{d^2w_0}{dx^2} \\ \frac{dv_0}{dx^2} \end{pmatrix}
=
\begin{pmatrix}
\cos\alpha x & 0 & 0 & 0 & 0 & 0 & \sin\alpha x & 0 & 0 & 0 & 0 & 0 \\
0 & \cosh m_1x & 0 & 0 & 0 & \sin m_1x & 0 & \sin m_2x & 0 & 0 & 0 & \cos m_2x \\
0 & 0 & \cosh n_1x & 0 & \sinh n_1x & 0 & 0 & 0 & \sin n_2x & 0 & \cos n_2x & 0 \\
0 & 0 & 0 & \cos\beta x & 0 & 0 & 0 & 0 & 0 & \sin\beta x & 0 & 0 \\
0 & 0 & n_1\sinh n_1x & 0 & n_1\cosh n_1x & 0 & 0 & 0 & n_2\cos n_2x & 0 & -n_2\sin n_2x & 0 \\
0 & m_1\sinh m_1x & 0 & 0 & 0 & m_1\cosh m_1x & 0 & m_2\cos m_2x & 0 & 0 & 0 & -m_2\sin m_2x \\
-\alpha\sin\alpha x & 0 & 0 & 0 & 0 & 0 & \alpha\cos\alpha x & 0 & 0 & 0 & 0 & 0 \\
0 & m_1^2\sinh m_1x & 0 & 0 & 0 & m_1^2\cosh m_1x & 0 & -m_2^2\cos m_2x & 0 & 0 & 0 & m_2^2\sin m_2x \\
0 & 0 & n_1^2\sinh n_1x & 0 & n_1^2\cosh n_1x & 0 & 0 & 0 & -n_2^2\cos n_2x & 0 & n_2^2\sin n_2x & 0 \\
0 & 0 & 0 & -\beta\sin\beta x & 0 & 0 & 0 & 0 & 0 & \beta\cos\beta x & 0 & 0 \\
0 & 0 & n_1^2\cosh n_1x & 0 & n_1^2\sinh n_1x & 0 & 0 & 0 & -n_2^2\sin n_2x & 0 & -n_2^2\cos n_2x & 0 \\
0 & m_1^2\cosh m_1x & 0 & 0 & 0 & m_1^2\sinh m_1x & 0 & -m_2^2\sin m_2x & 0 & 0 & 0 & -m_2^2\cos m_2x
\end{pmatrix}
\begin{pmatrix} A_1 \\ C_1 \\ D_1 \\ B_1 \\ D_2 \\ C_2 \\ A_2 \\ C_4 \\ D_4 \\ B_2 \\ D_3 \\ C_3 \end{pmatrix}
\quad \cdots\cdots(21)
$$

Therefore

$$C=(B\cdot L(x))^{-1}\begin{bmatrix}D(x)\\F(x)\end{bmatrix} \quad\cdots\cdots\cdots\cdots\cdots\cdots(24)$$

BY using equations (23), (24), the following can be obtained:

$$\begin{bmatrix}D(l)\\F(l)\end{bmatrix}=B\cdot L(l)\cdot C=B\cdot L(l)(B\cdot L(0))^{-1}\begin{bmatrix}D(0)\\F(0)\end{bmatrix}$$
$$=\begin{bmatrix}M_{11}, & M_{12}\\M_{21}, & M_{22}\end{bmatrix}\begin{bmatrix}D(0)\\F(0)\end{bmatrix}\quad\cdots\cdots\cdots\cdots(25)$$

Where the above takes the form of

$$\begin{bmatrix}M_{11}, & M_{12}\\M_{21}, & M_{22}\end{bmatrix}B\cdot L(l)(B\cdot L(0))^{-1}\quad\cdots\cdots\cdots\cdots(26)$$

then, $M_{12}$, $M_{21}$, $M_{12}$, $M_{22}$ are each a matrix of $6\times6$.
From equation (25),

$$D(l)=M_{11}\cdot D(0)+M_{12}\cdot F(0)\quad\cdots\cdots\cdots\cdots(27)$$

$$F(l)=M_{12}\cdot D(0)+M_{22}\cdot F(0)\quad\cdots\cdots\cdots\cdots(28)$$

By using equations (27), (28) and applying the symmetry of stiffness matrix. the following equation can be obtained:

$$\begin{bmatrix}F(0)\\F(l)\end{bmatrix}=\begin{bmatrix}K_{11}, & K_{12}\\K_{21}, & K_{22}\end{bmatrix}\begin{bmatrix}D(0)\\D(l)\end{bmatrix}=K\begin{bmatrix}D(0)\\D(l)\end{bmatrix}\quad\cdots\cdots(29)$$

where

$$\left.\begin{aligned}K_{12}&=(M_{12}M_{22}^{-1})^{-1}\\K_{12}&=K_{21}=M_{22}^{-1}K_{22}\\K_{11}&=M_{22}^{-1}(K_{21}-M_{21})\end{aligned}\right\}\quad\cdots\cdots\cdots\cdots(30)$$

K in equation (29) is the stiffness matrix for vibration of beam having uniform cross section. Furthermore, when there is a concentrated mass m at the starting point or ending point of beam, the following matrix should be added to $K_{11}$ or $K_{22}$.

$$\begin{bmatrix}-m\omega^2 & & & & & \\ 0 & -m\omega^2 & & & & \\ 0 & 0 & -m\omega^2 & & & \\ 0 & m\omega^2 z_G & -m\omega^2 y_G & -J_x\omega^2 & & \\ -m\omega^2 z_G & 0 & m\omega^2 x_G & 0 & -J_y\omega^2 & \\ m\omega^2 y_G & -m\omega^2 x_G & 0 & 0 & 0 & -J_z\omega^2\end{bmatrix}\quad\cdots\cdots\cdots\cdots(31)$$

Moreover, when the joint is spring supported, $k_x$, $k_y$, $k_z$, $k_{mx}$, $k_{my}$, $k_{mz}$, etc. should be added to the terms in diagonal line of the matrix for that joint.

2.3 Solution of vibrational stiffness equation

Using the equation (29) derived in the preceding section. the stiffness matrix for each member will be prepared. These matrixes and external loads are placed in absolute coordinates, by carrying out transformation of Wrdinatcs. Then the stiffness matrix for the entire structure will be prepared by adding the matrices of ail joints. When the inversed matrix of this stiffness matrix for the entire structure is obtained and when it is multiplied by the external loads, the vibrational displacement and vibrational modes for each joint in that structure, in the case of circular frequency $\omega$, can be obtained. By changing this $\omega$ little by little and repeating the above calculations. it is possible to obtain the resonance curve of that structure. In the actual computational programs, calculations for several vibrational frequencies art carried out simultaneously.

Because the stiffness matrix of the entire structure, in the case of three-dimensional framed structures, will become a matrix, of a size 6 times the number of general joints, it is not possible to directly calculate& this inversed matrix, from the standpoint of computer capacity, when a structure contains very many joints. Therefore, the author has adopted the unit splitting method, which is generally used. The author. however, invented a method which will eliminate the need of splitting the structure into several units by the user himself, which is very troublesome work and is considered as shortcomings of unit splitting method. Since the details of this system had already been presented[12], its explanation will be omitted here. Furthermore, assumptions concerning the relation between the structural member coordinate system and the absolute coordinate system. and the releases at joints and at ends of members are the same as the above reference[12].

## 3. Program

The program was prepared in accordance with the contents as explained above. The points which were specially considered in the preparation of this program are as follows:

1. The sectional properties and dead weight of each member will be automatically calculated by the input of in dimensions and specific gravity.
2. The vibrational modes can be drawn by the plotter, thereby the results of analytical work can be quickly and appropriately grasped by appealing to vision.
3. Attempts have been made to minimize the user's efforts by providing the error messages at each check point, thereby permitting early detection of erroneous data.
4. Considerations have been made to permit computational capacity of structures having large number of joints and members. At present, the maximum computational capacity is as follows:

   Number of joints: 800
   Number of members: 1,600
   Number of loading conditions: 16

the computer employed in this system is UNIVAC-1108, and the plotter is CALCOMP.

## 4. Example of applications

4.1 Example of vibrational analysis of radar mast

An example of analysis of radar mast in an escort ship, as shown in Fig. 2, will be introduced here. This

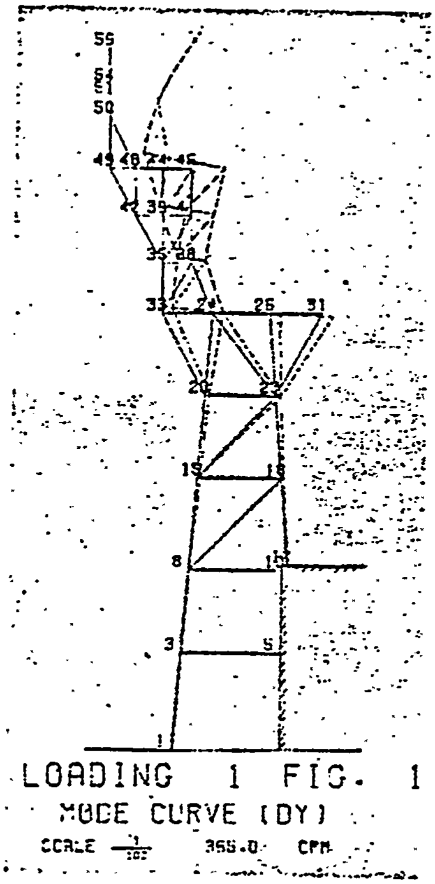



Fig. 2-(a) Vibration mode of radar mast (first order in longitudinal direction)

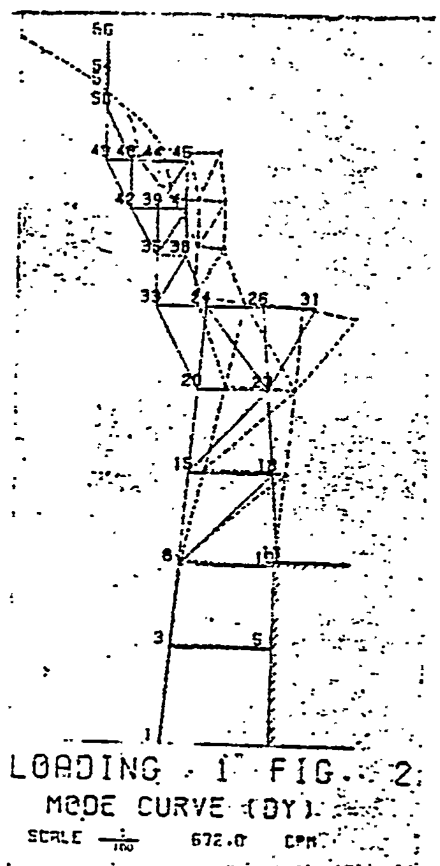



Fig. 2-(b) Vibration mode of radar mast (second order in longitudinal direction)

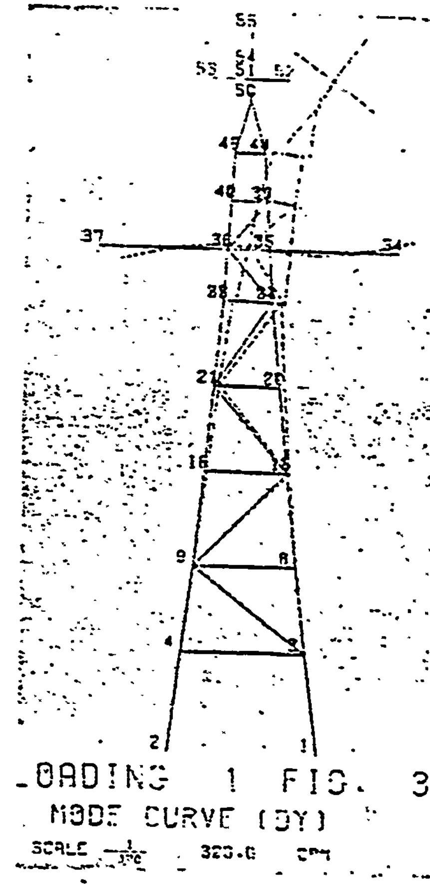



Fig. 2-(c) Vibration mode of radar mast (first order in port and starbord direction)

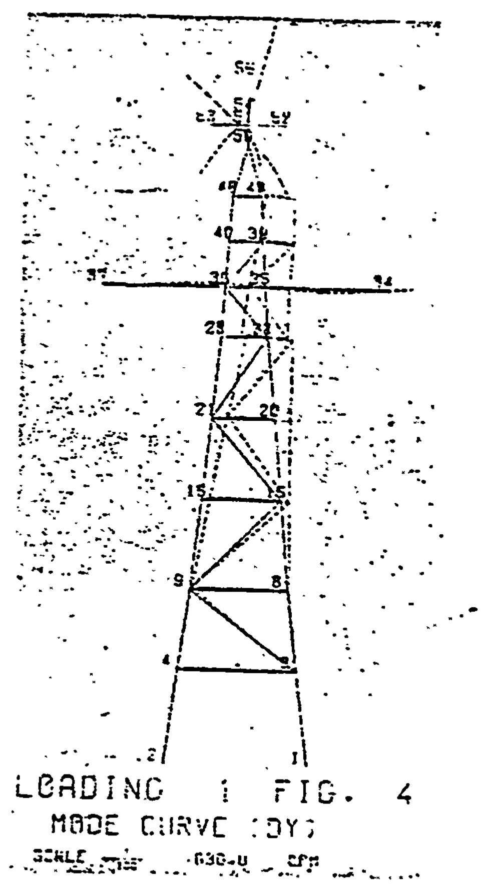
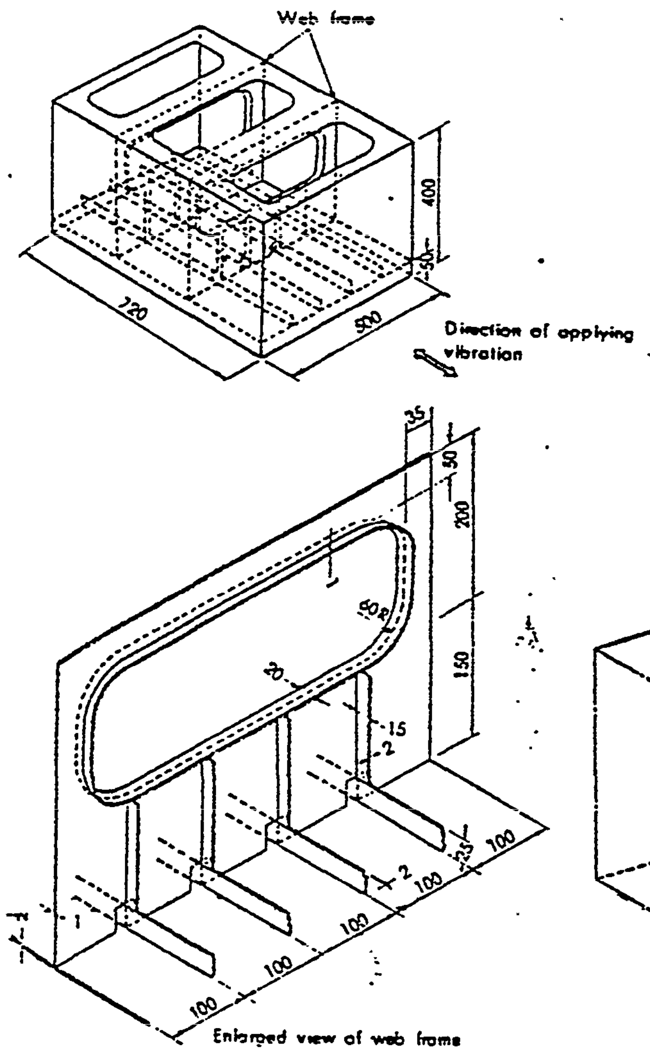



Fig. 2-(d) Vibration mode of radar mast (second order in port and starbord direction)




(note Material: Acryl
**Elastic modulus: 460 kg/cm²**

Fig. 3 **Model** of experiment (mm)

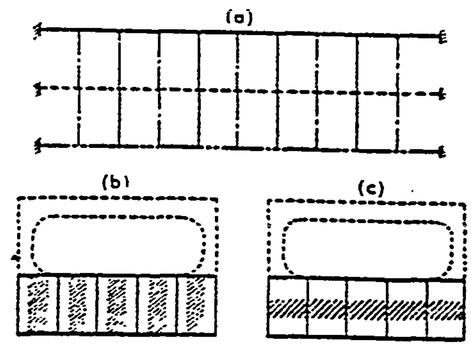



**Fig. 4 Process of modification to web frame structure**

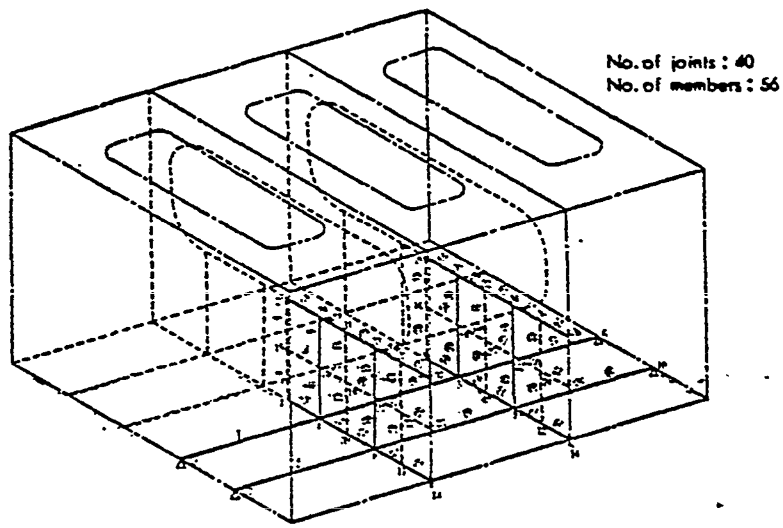



Fig. 5 Frame structure of tank for calculation

radar mast is a three-dimensional framed structure made up of steel pipes. The radar and other equipment are attached to 14 joints **near** the top of the mast. and they jic considered to constitute a concentrated masses. The dead weight of steel pipes, which constitute the framed structure will be computed as distributed mass in the program by inputting pipe diameter, thickness and specific gravity, and the distributed mass will be applied to each member. More over, **since** the dimensions of each member are given the sectional properties of each member will be automatically computed in the Program. In addition. the coordinate values and boundary conditions of each joint will be input. As for the hud. forced displacements. consisting of sinusoidal waves of same amplitude, were applied to 10 support hunts at the base of radar. in the directions along the length of **ship** as well as toward port and starboard.

The 'computational results of vibrational modes are Drawn by the plotter as shown in Fig. 2 The resonance Points in port and starboard directions were 320 cpm for first order and 630 cpm for second order. and in Iongitudinal direction 365 cpm for first order and 672 cpm for second order. Moreover, because the weight distribution of this mast is not symmetrical longitudinally, a **small** amount of torsion will be generated in lateral vibrations.

4.2 Example of vibrational analysis of web frame in tank

Recently. with the increase in ship size. there are sometimes damages of web frames **in** tank near the stem. due to vibrational forces. In order to investigate the behavior of vibration on web frames in tank, a model test was done by the technical research laboratory of our company. A comparison between the test results and the analytical results by this program ZVIBRA has been made.

(I) Model test

A test model shown in Fig. 3 consists of tank, made of acrylic resin. in which **2** web frames were installed. The model was mounted on the vibrator base, **then** vibration was applied on to **the model** in longitudinal direction (perpendicular to surface of web frame), and

vibrational responses and vibration modes were measured for the cases of with and without water in the tank.

Measurements were made in the following manner, namely. 8 accelerating type pick-ups (weight: 1.5 g) were attached to the web frames, and pick-up was fixed onto the vibrator base. By changing the vibrational frequency both acceleration and phase were measured for each vibrational frequency. The positions where the pick-ups were attached arc shown in Fig. 6.

(2) Computation by this program

Because this program is applicable only to framed structures, it is necesary to modify the type of structure where it is close to a plate, as in the case of web frame, into a model of frame-type structure. According to test results (Fig. 6), it is clear that the pane1 itserf between stiffeners also vibrates considerably. Therefore, the conventional method of solving the web frame stiffness problems. in assuming the web frame to be substituted by a grillage structure made up of stiffeners with appropriate effective width, as generally used, is not useful. Therefore, the pane1 between stiffeners was also assumed lo constitute a part of the grillages, and the fixing condition of web frame ends was also taken into consideration. Then computations were carried out with the assumptions as below:

1. The portion shown by the dotted lines in Fig. 4-(b) will be ignored. and it is assumed that the web frame is made up of panels and stiffeners shown by solid lines only.
2 The panel between stiffeners is assumed ‘to constitute a part of grid. thereby the web frame is assumed to be a grillage structure in Fig. 4-(a). Further, lines in Fig. 4-(a) show the following items:

Heavy continuous line:

Stiffness and weight will be determined by assuming a member made up of a vertical stiffener plus an effective width equal to a half of the panel between stiffeners.

Alternate long and short dash line:

The shaded portion in Fig. 4-(b), namely, stiffness and weight will be computed by taking up the central tral half of the panel between stiffeners.

Dotted line:

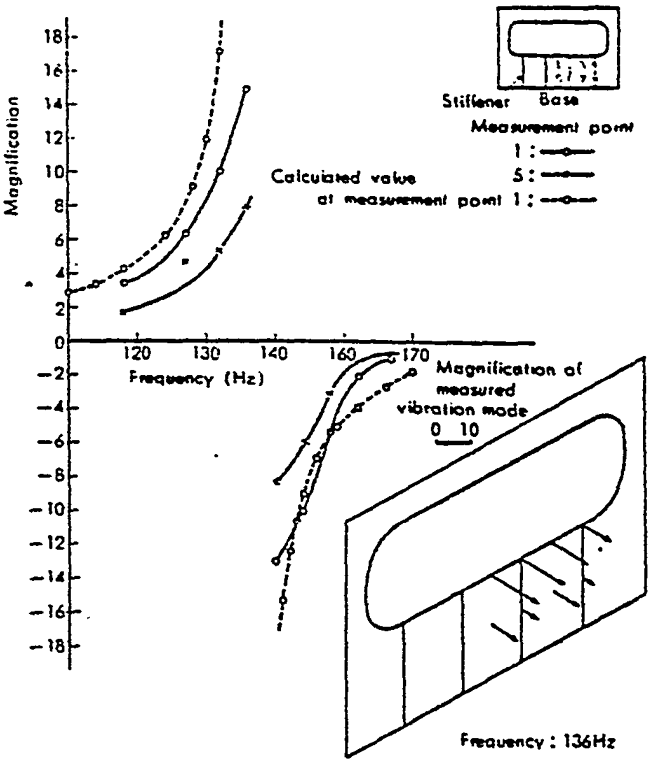
An area having a width equal to 1/2 of panel in horizontal direction is taken up in the middle of panel (shaded portion in Fig. 4-(c)), and it is assumed that there is a member which has stiffness equivalent to the above dimensions but has no weight.

Light continuous line:

The face plate only on upper edge, and its stiffness and weight will be determined.

Alternate long and two short dashes line:

The lower plate of web frame and 1/2 of tank bottom plate are assumed to contribute to the stiffness and only the latter item will be accounted for weight.




(Note) Magnification=$\dfrac{\text{Measured acceleration}}{\text{Acceleration on bibrator base}}$

(Negative sign if in inverse phase)

Fig. 6 Resonance curves and vibration **mode of web frame in air**

3. Both left and right ends of the grillage shown in *Fig*. 4-(a) are supposed to be rigidly fixed to both walls of sufficiently rigid model tank.
4. The lower end of web frame which is assumed to be of grillage structure is rigidly fixed to the tank bottom stiffeners at the bottom of vertical stiffeners. and the stiffness and weight of the tank bottom stiffeners is computed by including the entire effecive width of the panel.
5. The entire model is handles as a framed structure shown in *Fig. 5*. In this case since the model is symmetrical about the center of tank, only a hail of the above model will be considered and at the center only a half of the stiffness and weight of a member is taken. and its rotatory displacement was ssumed to be zero.

As for the loads used in computation. an attempt was made to produce the same conditions as in the case of test by applying forced displacements of sinusoidal type onto joints 3, 6, 7, 10, 13, 14. 25,26, 37.38, in *Fig. 5*.

(3) Comparison of test and computational results

Frequency response curves and vibration modes of the model tested in **air** arc shown in *Fig. 6*, and the frequency response curve was plotted from the computations at measurement point-i. Further, in Fig. 7 a comparison is made of measured and computed

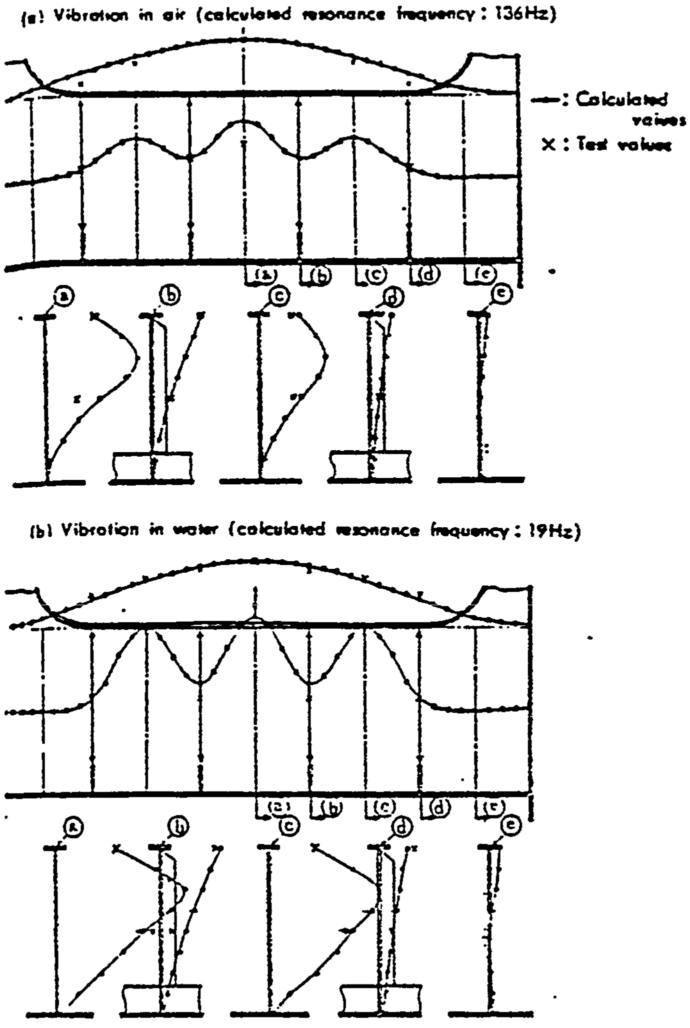



Fig. 7 Measured and computed vibration mode of web frame

vibration modes. both in air and in water. However. in the case of computation of vibrations in water. the virtual mass of water was estimated from the frequency of both in air and in water according to tests. and those values were used in the computation.

As can be seen from Fig. 6, the calculated value of resonance frequency is 136Hz which agrees fairly well with the test value. However, the magnification of vibrations shown to be of large value near the resonance point. because damping factor is not taken into account, and the calculated values approach to the test values as the frequency moves away from the resonance point. In Fig. 7, when the test and computative values are taken equal at measurement point-l, a comparison of the two values at other points is shown. As can be seen from the above, the form of vibration mode agrees fairly well with test results. and the mode from computation clearly shows that the panel between stiffeners is in coupled vibration. Examples of output mode by the plotter in drawing the vibration mode curves are shown in Fig. 8.

4 3 Example of analysis of coupled vibration between hull and bottom

As one method of analyzing the vibration of hull, the' hull can be considered as a beam with varying cross section. and it has been ascertained that computation based on the above assumption produces adequately precise results. if the degree of vibration is rather low. However it is known that[3] in high degree vibration having more than 4 nodes or so, unless the coupled vibration with local vibrations arising from bottom. etc. is-not taken into account, it is difficult to carry out accurate analysis.

As an example of analysis.of coupled vibration between hull and bottom (double bottom), the case of Ship A (a bulk carrier) will be explained below:

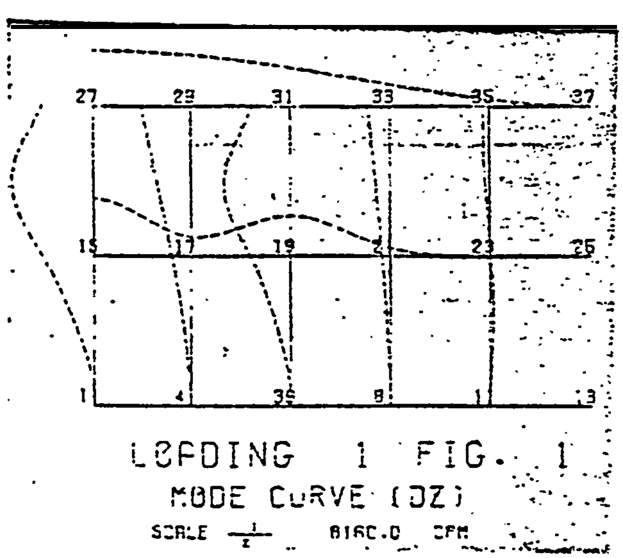



Fig.8.(a) Output from CALCOMP plotter of vibration mode curve of web frame in air (1)

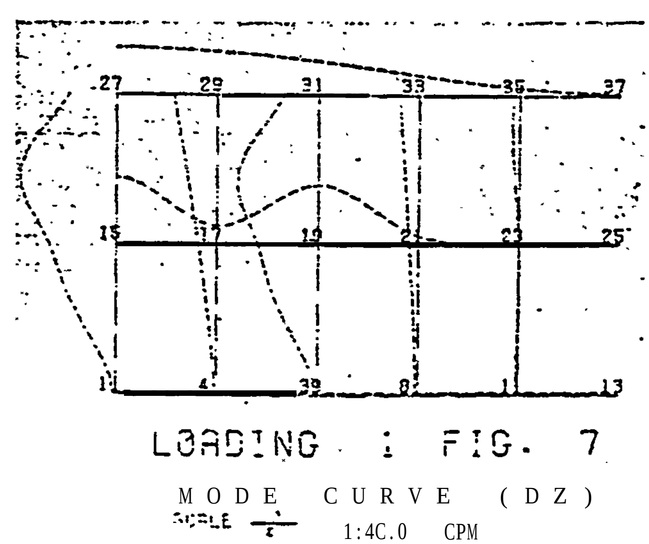
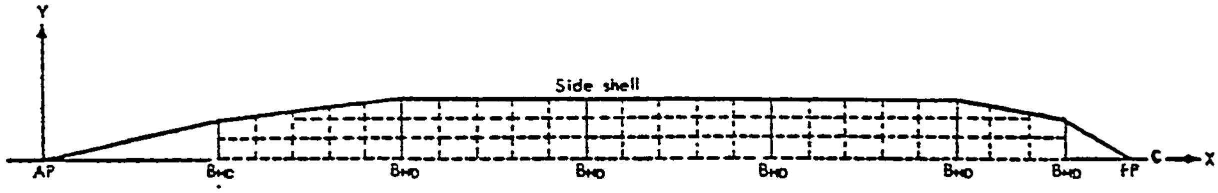



Fig. 8-(b) Output from CALCOMP plotter of biration mode curve of web frame in air (2)




(Nale) No. of joints: 98. No. of members: 164

**Fig. 9** Modification to plane grid **of side shell. transverse bulk had and double bottom**

(1) Computative assumption

In **carrying** out the analysis the following assumptions have been made:

1. The hull will be approximated by a plane grid as shown in Fig. 9. **Since the hull** is a symmetrical structure at port and starbord. of the hull need be considered. Namely, by letting the vertical displacements of all joints on the centerline of ship as well as the rotatory displacements around Y axis free. and also by letting other components displacements constrained, the results would be the same as if both sides were computed. As for the means of approximating the structure by plane grids. the double bottom structure is shown by a plane grid with dotted lines. and both side structure and transverse bulkheads by a grid with continuous lines.
2. The stiffness of each structure was-taken as below:

   Double bottom:

   The double bottom was split into 4 transverse girders and 3 longitudinal girders, then their stiffness was computed. The torsional stiffness was computed by using a value assuming that the double bottom **is** made of plates with anisotropic plate.

   Side shell:

   One half of the longitudinal stiffness of ship {moment of inertia and the effective shearing area used in the so-called longitudinal strength of ship) was used. For the torsional stiffness of double bottom, the torsional stiffness of hopper, which is connected with the double bottom floor was used.

   Transverse bulkhead:

   The bending stiffness was taken to be very large, and computing the shearing stiffness the cross sectional area of bulkhead plate was used.
3. The distribution of hull weight has been allocated as below:

   Double bottom:

   The dud weight of double bottom and the ballast within double bottom **were uniformly dis**tributed to transverse **girders.**

   **Side** shell:

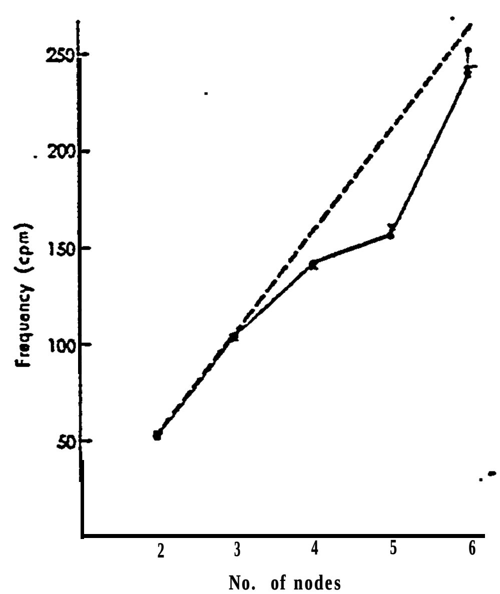
   Both hull weight and ballast other than those of the double bottom were distributed, according to the respective distribution in longitudinal din tion. so that the resultant distribution in o member would be uniform.

   Transverse bulkhead:

   The dead weight of transverse bulkhead is to included in the side shell.
4. Virtual mass of the water, as obtained using t method of Lewis[6] was distributed to the ion tudinal girders of double bottom, and where the is no longitudinal girder. it was distributed to t side shell.

**Table : Comparison between calculated and measured natural frequencies of ship-A**

| Node / Category | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| measured values | 53 | 103 | 140 | 160 | (252 |
| Calculated values | 52 | 104 | 141 | 156 | (239 (251 |

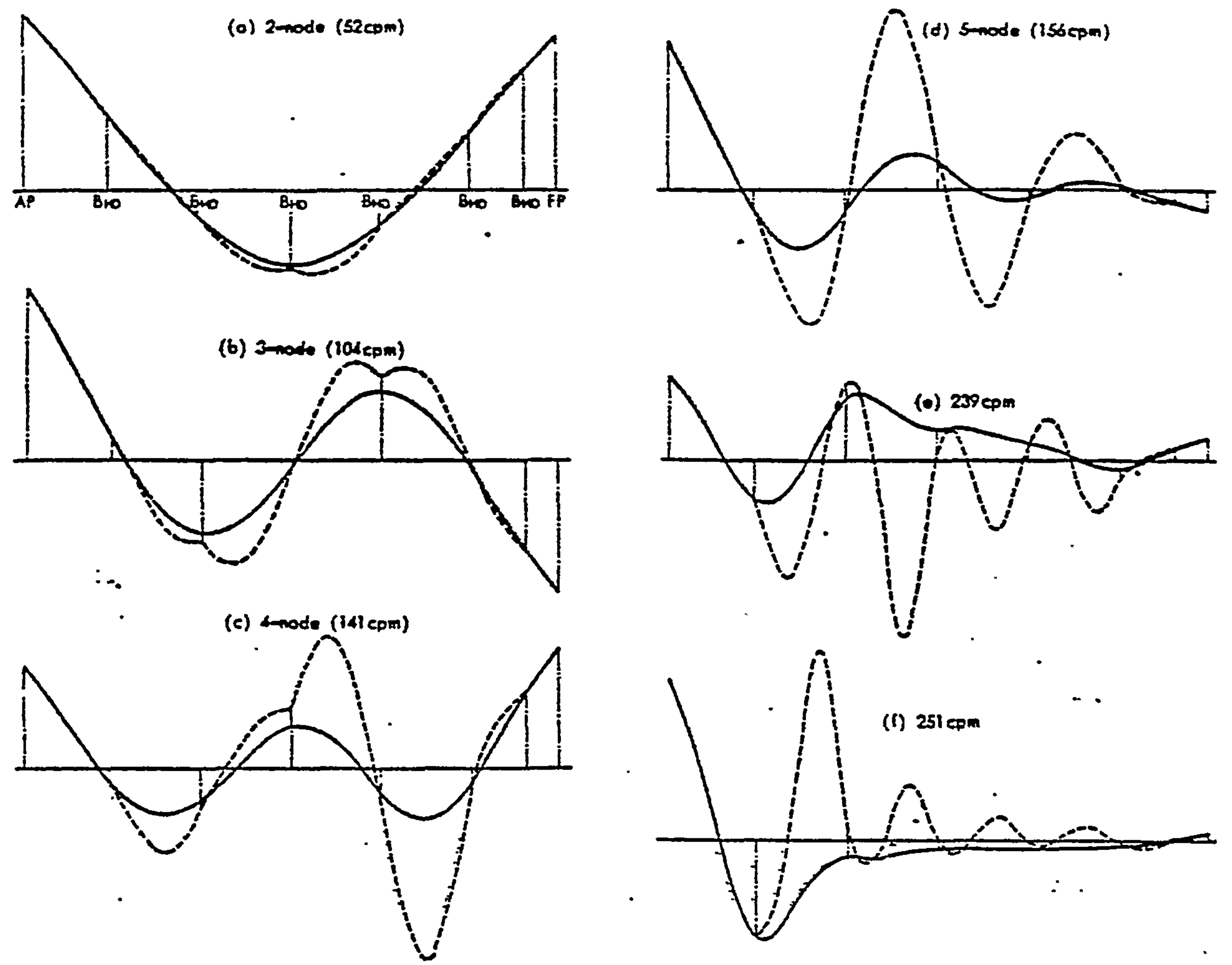



(Note) - - -: calculated values

X : Measured

-------: calculated values uunder assumption that hull is abeam with varying cross section.

**Fig. 10 Natural frequency** versus number **of** nodes c ship-A




(N0te) ———: Mode at ship side
- - - -- --: Mode at centerline of double bottom

**Fig. 11 Calculated mode curves of ship-A**

5. As for the load. vertical forces of sinusoidal form were applied onto joint at stern end.

(2) Results of analysis and comparison with actual measurement results

Under the above assumptions. the vertical hull vibration of Ship A was computed. Table I contains the comparison between calculated and measured values of natural frequencies, and Fig. 10 shows the comparison between calculated and measured results of natural frequency curves. The dotted line in the above figure represents the calculated values. when the hull is assumed of a beam having varying cross section. Moreover. thc frequency with 6 nodes in the above table is actually not of a mode with 6 nodes. and because only the stern is vibrating, its frequency is equivalent to 6 nodes but not of 6 nodes in strict sense.

As can be seen from Fig. 10, the values obtained from calculations agree very well with measured values. when calculations were made by assuming a beam with varying cross section. as a matter of course the coupling effects between hull and double bottom can not be accounted for. and because the resonance frequency varies linearly as the number of nodes increases. the calculated results will differ considerably from the measured values starting from around the 4th node.

Vibration modes of side shell and centerline of double bottom at the resonance point. according to the calculation of this system is shown in Fig. II. It can be seen that the vibration of double bottom increases starting from around the 4th node. Moreover. the fact that at resonance points of 239 cpm and 251 cpm the nodes on side shell disappear and only the stern portion vibrates will provede a good explanation on the actual cases where stem vibrations frequentlv occur in higher degree vibrations.

## 5. Conclusions

With the stiffness matrix method, a general purpose program ZVIBRA for vibrational analysis of three-dimensional and two-dimensional framed structures has been prepared. Its outline and several examples of its application have been presented, showing that

there have been good agreements between theory and test results. As a target for future studies, it is necessary to continue research which takes into account of the damping factor of vibration.

## REFERENCES


(1) S. Timoshcnko: Vibration Problems in Engineering. D. Van Nostand Company, Inc., Printston N. J.. New York (1937)

(2) I. Neki: Matrix Method of Structural Anaiysis of Framed Structures and its Application, Ishikawajima-Harima Engineering Review Vol. 9 No. 3, May 1969, p. 266.

(3) I. **Neki: Matrix** Method of Structural Analysis of Framed Structures and Examples of its Application. IHI Engineering Review Vol. 3 No. 4 March 1970 p. 7

(4) Trail-Nash and Collar: The Effects of Shear Flexibility and Rotatory-Inertia on the Bending Vibrations of Beams Quart. Journ. Mech. and Applied Math., Vol. 6

(5) H. **Nagai: Natural** Vibration of Beam with Varying Cross Section, IHI Engineering **Review** Vol. 8 No. 40 March 1968 p. 183

(6) K. Suetsugu: On Vibration of Ship Bottom. Kansai Shipbuilding Association, No. I I I October 1963

(7) F. M. Lewis: The inertia of the water surrounding the vibrating ship, Trans. S. N. A. M. E. Vol.37 (1929)

## V. RECOMMENDATIONS

The current upgrading of facilities and equipment related to Numerical Control Steel Fabrication, Sub-task 2.2 of the T.T.P., has produced a system which is capable of increasing the tons per month of fabricated steel. The related N/C software package, SPADES, currently provides more data than the system is utilizing. It is the common opinion of IHI and key Levingston Production and Engineering personnel that an N/C system of scaled body plan mold lofting be implemented through the installation of a numerically controlled drafting machine in the mold loft.

Please see Reference 1 which documents the rationale for this decision.

## VI. REFERENCES

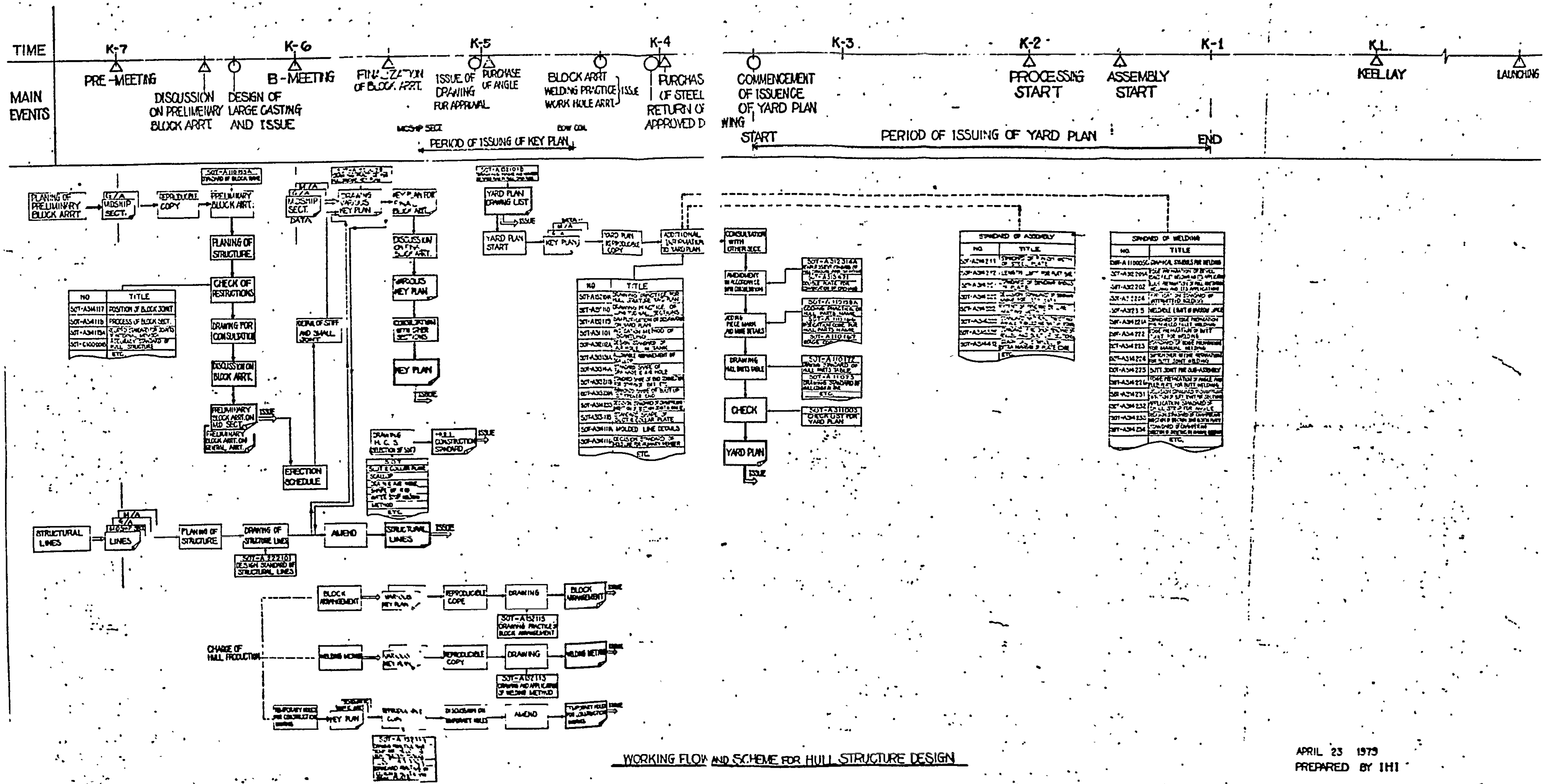

1. Study of LSCo N/C System and Description of IHI N/C System-IHI
2. Comparison Analysis: LSCo vs. IHI N/C Systems-Levingston
3. Memo: RW Taylor to Clyde LaRue; April 24, 1979; N/C Drafting Machine
4. Study of SPADES and LSCo Utilization-IHI
5. System Change Analysis
6. Memo: K. Honda to Bob. Peterson, June 20, 1979; Merits for Installation of N/C Drafter Machine.

APPENDIX M

IHI WORKING FLOW AND SCHEME FOR HULL STRUCTURE DESIGN

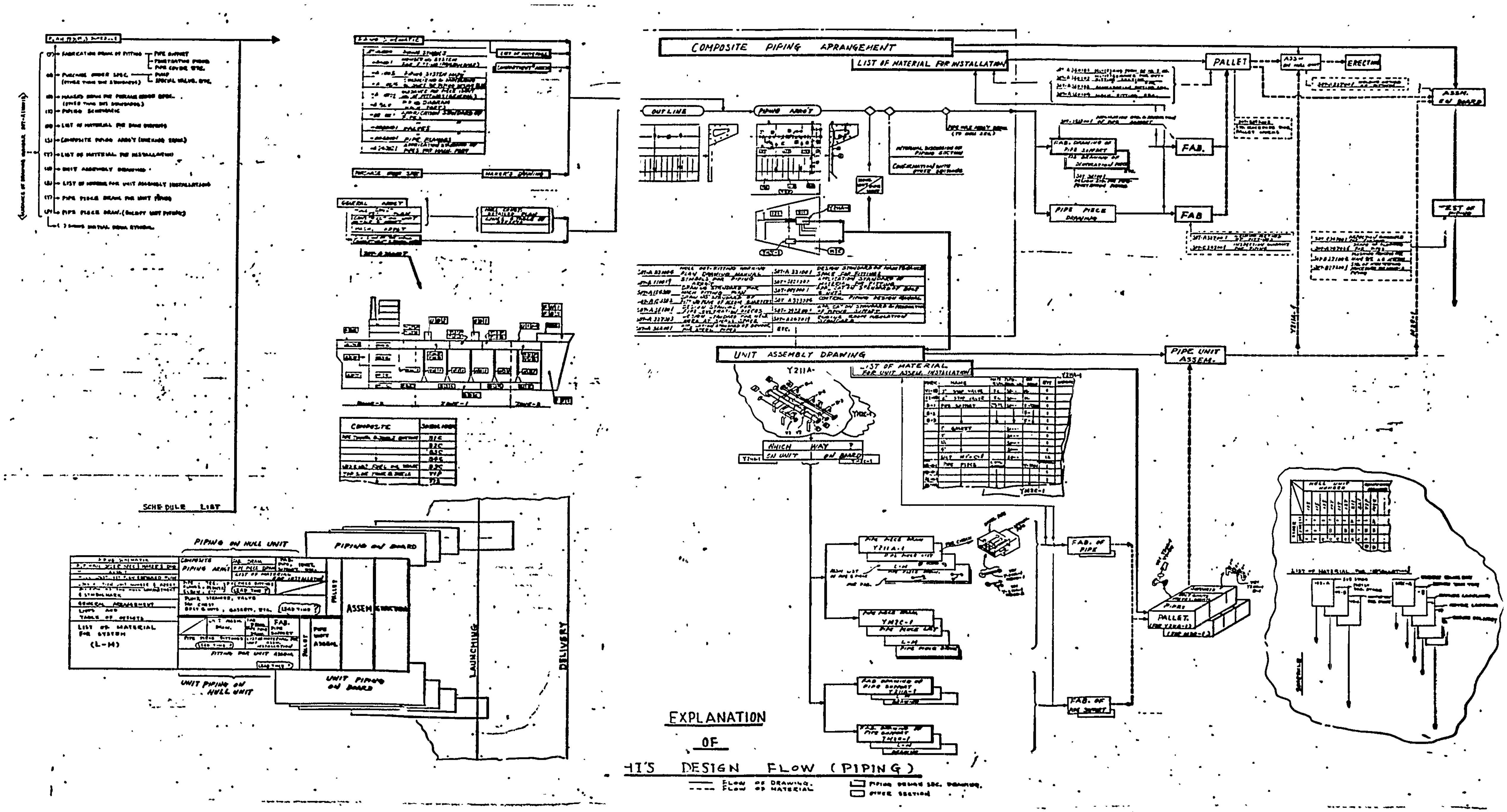
APPENDIX N

EXPLANATION OF IHI'S DESIGN FLOW (PIPING)




WORKING FLOW AND SCHEME FOR HULL STRUCTURE DESIGN

APRIL 23 1979
PREPARED BY IHI




EXPLANATION

OF

HI'S DESIGN FLOW (PIPING)